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Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery – Lake Pend Oreille, Idaho

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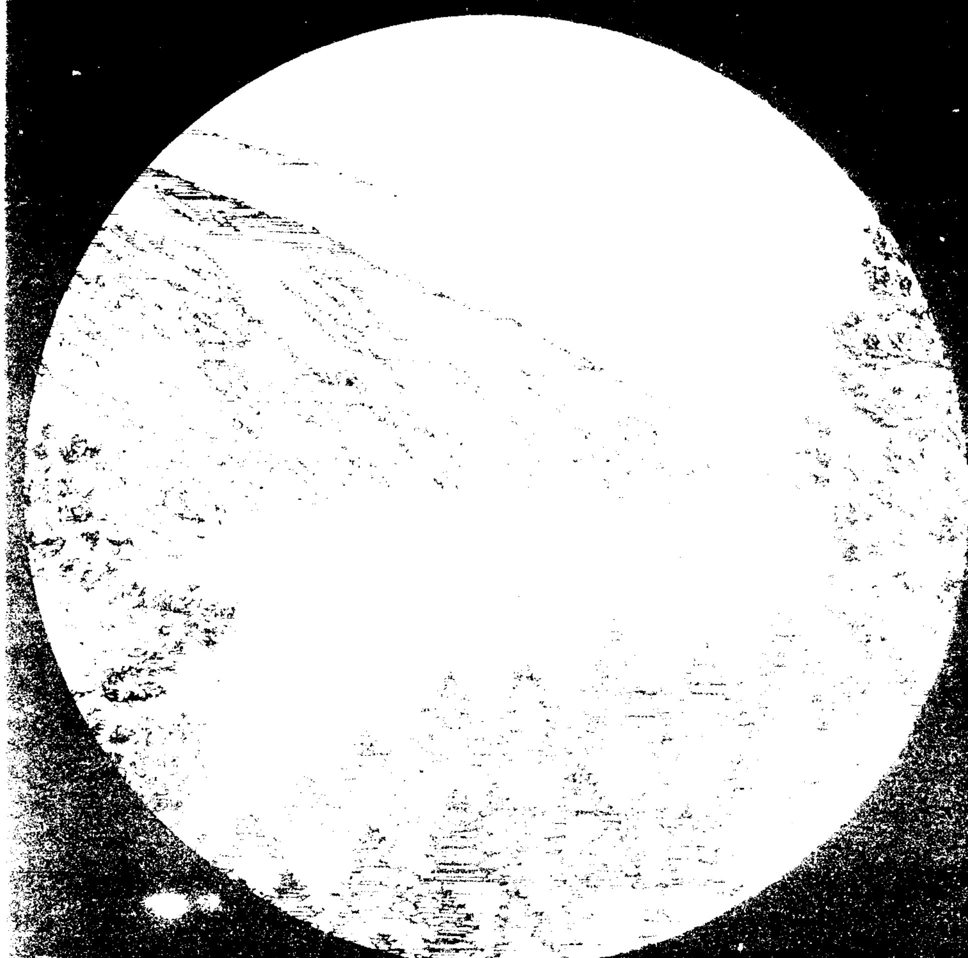
May 1988



Annual Report 1987

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KOKANEE STOCK STATUS AND CONTRIBUTION OF CABINET GORGE HATCHERY
LAKE PEND OREILLE, IDAHO

Annual Progress Report FY 1987

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ABSTRACT

Estimated kokanee Oncorhynchus nerka abundance in Lake Pend Oreille was 6.01 million during late summer- 1987. This estimate is 40% higher than the 1986 estimate and is the second largest population estimate since 1977. Higher abundance is predominantly a result of enhanced fry survival and recruitment.

Hatchery-reared fry contribution was 22Z of total fry recruitment in 1987, compared to 8Z in 1986, and resulted from a fivefold increase in survival. Much of this improvement can be attributed to the large (52 mm) fry produced at Cabinet Gorge Hatchery in 1987 and represents the first measurable contribution of the new hatchery to the kokanee rehabilitation program. Survival of hatchery-reared fry released into Clark Fork River was nearly one-half that of fry released into Sullivan Springs due to poor flow conditions and potentially high predation during emigration from Cabinet Gorge Hatchery to Lake Pend Oreille.

Wild fry survival was enhanced by Carly availability of forage (cladoceran zooplankton) during fry emergence in late spring. Cladoceran production began three weeks earlier in 1987 than 1986, which resulted from reduced Mysis abundance and earlier thermal stratification of Lake Pend Oreille, which helped segregate cladocerans from mysid predation.

Kokanee fry otolith coding was evaluated to provide a reliable long-term mark. Analysis of daily growth increments on otoliths was used successfully in 1987 to differentiate fry from various release sites. The technique will be refined during 1988 to include coding fry otoliths with water temperature fluctuations during hatchery residence.

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INTRODUCTION

Lake Pend Oreille supported the most popular kokanee salmon *Oncorhynchus nerka* fishery in Idaho from the 1940s until the early 1970s. The sport and commercial fishery yielded an average annual harvest of one million kokanee during 360,000 hours of angling effort from 1951 to 1965 (Ellis and Bowler 1979). Sport anglers enjoyed catch rates as high as 3.5 fish/h during the mid-1960s. Annual kokanee harvest declined from 1965 to 1985, resulting in an annual harvest of less than 100,000 fish, with a mean catch rate of approximately one kokanee/h. Goals of the kokanee rehabilitation program include an annual harvest of 750,000 kokanee averaging 25 cm long and catch rates averaging 2 fish/h. In addition to providing an important fishery, kokanee are the primary forage for trophy Kamloops (Gerrard) rainbow trout *Salmo gairdneri* and bull trout *Salvelinus confluentus* in Lake Pend Oreille. Goals of the trophy rainbow rehabilitation program include an average size of 3.2 kg per fish, with trout over 9 kg making up 5% of the harvest.

Several factors contributed to the initial decline of kokanee abundance. Hydropower development adversely impacted spawning success of kokanee salmon. Albeni Falls Dam was completed in 1952 by the Army Corps of Engineers as part of the Bonneville Power Administration (BPA) network. Located on the Pend Oreille River approximately 35 km downstream of Lake Pend Oreille, Albeni Falls Dam raised lake levels by 4 m. Annual winter drawdown, which averaged 1.3 m from 1951 to 1968, increased embryo mortality by exposing redds of lakeshore-spawning kokanee (Bowler et al. 1979). Cabinet Gorge Dam was constructed on the Clark Fork River (rkm 24) for power generation by Washington Water Power Company (WWP). Completion of this dam in 1952 blocked an important kokanee spawning run into the Clark Fork River and tributaries. Declining kokanee abundance may have been accelerated by commercial and sport fishing. The establishment of opossum shrimp *Mysis relicta* in Lake Pend Oreille during the mid-1970s adversely impacted kokanee recruitment. Idaho Department of Fish and Game (IDFG) introduced *Mysis* in 1968 to enhance the kokanee forage base. The expected response of increased juvenile kokanee growth and survival did not occur because mysids competed with postemergent kokanee fry for cladoceran zooplankton. Competition with and predation on zooplankton by mysids delayed production of two cladocerans (*Daphnia* and *Bosmina*) that are essential juvenile kokanee forage during the first few weeks of feeding (Rieman and Bowler 1980). Increased growth of older kokanee did not occur because of spatial segregation between *Mysis* and feeding kokanee. Mysids remain in deep water during daylight hours and migrate to surface waters at nig't. Kokanee are visual feeders and are thus able to feed on the shrimp for short periods during dawn and dusk only (Rieman 1977).

Interagency efforts to rehabilitate the kokanee fishery began during its initial decline. In 1967, the Army Corps of Engineers adopted a policy for operation of Albeni Falls Dam to minimize water level fluctuations during kokanee spawning and incubation. IDFG restricted kokanee sport harvest and terminated the commercial fishery in 1973.

Hatchery production of kokanee for Lake Pend Oreille was established by 1974 and helped stabilize population numbers. Delayed planting of hatchery fry until midsummer to avoid early season forage deficiencies increased hatchery fry survival up to 13 times over wild fry (Bowler 1981). Hatchery production kept the fishery from total collapse, but rearing capacity of existing hatcheries was inadequate to rebuild the fishery. Prior to 1985, hatcheries could provide only 6 to 8 million kokanee fry annually for Lake Pend Oreille. Research indicated that releases of up to 20 million fry annually may be necessary to restore the fishery to historic levels (Rieman 1981).

In an effort to enhance Lake Pend Oreille kokanee production, Cabinet Gorge Hatchery was built on the Clark Fork River 4 km below Cabinet Gorge Dam. Cost of the hatchery was approximately $2.2 million and represented a cooperative effort among BPA, WWP and IDFG. BPA funding was from on-site resident fish mitigation funds mandated by the Northwest Power Act of 1980. Construction and evaluation of Cabinet Gorge Hatchery is specified by Measure 804(e)(5) of the Columbia River Basin Fish and Wildlife Program (NWPPC 1984). Cabinet Gorge Hatchery was operational by November 1985 and at full capacity will provide up to 20 million kokanee fry for release into the Pend Oreille system. Rebuilding the kokanee population to attain the goal of over 750,000 kokanee harvested annually and 300,000 hours of effort will depend on production from this hatchery.

This research project was developed by IDFG in cooperation with BPA and WWP to evaluate the contribution of Cabinet Gorge Hatchery to the Lake Pend Oreille kokanee stock and fishery and to provide recommendations for optimizing kokanee production and survival. BPA provided the majority (>90%) of funding for this project. Funds from WWP were used for the fry marking study that examined the feasibility of differentially marking kokanee release groups. WWP also provided funding assistance for evaluating kokanee fry release strategies, which included providing requested discharge rates from Cabinet Gorge Dam.

OBJECTIVES

1. To monitor the kokanee population in Lake Pend Oreille as production increases from Cabinet Gorge Hatchery, including population size, age composition and hatchery-wild composition.

2. To monitor changes in kokanee age composition, growth and survival in relation to population density and carrying capacity of Lake Pend Oreille.

3. To evaluate kokanee release strategies by estimating kokanee fry emigration rate, timing and survival with respect to river discharge, diel timing, moon phase, release site, fish size and number of fry released.

4. To determine feasibility of differentially marking fry release groups by evaluating retention and mortality associated with various marks.

5. To obtain index information on natural spawning kokanee to monitor contribution of hatchery-reared fish.

6. To monitor the zooplankton community in Lake Pend Oreille and relate to changes in kokanee abundance.

RECOMMENDATIONS

1. Midsummer fry releases into Clark Fork River should be avoided unless 25,000 ft^3/s or higher nighttime flows can be maintained for two nights followin each release. Nighttime flows should be initiated with a 5,000 ft /s surge or pulse to simulate a freshet. Midsummer fry releases into Clark Fork River during lower nighttime flows may be necessary to test specific research hypotheses, but should be limited to 1 million fry/release.

2. To ensure adequate nighttime flows, fry releases into Clark Fork River may have to coincide with the end of spring runoff. During poor water years, this may require early to mid-June releases- Growth of these fry should be maximized in the hatchery to increase their ability to forage effectively in Lake Pend Oreille. Early season fry releases into Clark Fork River should not exceed 3 million kokanee until survival and recruitment are evaluated.

3. Fry releases into Sullivan Springs Creek should not occur before thermal stratification of Lake Pend Oreille (typically mid-July) to ensure adequate forage. A minimum of 3.2 million fry should be released into Sullivan Springs each year to maintain an adequate egg supply.

4. Fry survival and recruitment associated with open-water and in-shore fry releases into Lake Pend Oreille should be evaluated with surplus fry not needed to maintain or enhance Sullivan Springs and Clark Fork River runs.

5. The best long-term mark for evaluating fry release strategies appears to be coding kokanee otoliths with water temperature manipulations during hatchery residence. This technique should be refined in 1988 and efforts made to upgrade hatchery capabilities to optimize marking potential (i.e., provide 5°C thermal gradient for 2-week period and thermally isolated raceways).

STUDY AREA

Lake Pend Oreille is located in the panhandle of Idaho (Figure 1). It is the largest lake in Idaho, with a surface area of 383 km^2, mean depth of 164 m and maximum depth of 351 m. Mean surface elevation of Lake Pend Oreille is 629 m. The Clark Fork River is the largest tributary to Lake Pend Oreille. Outflow from the lake forms the Pend Oreille River.

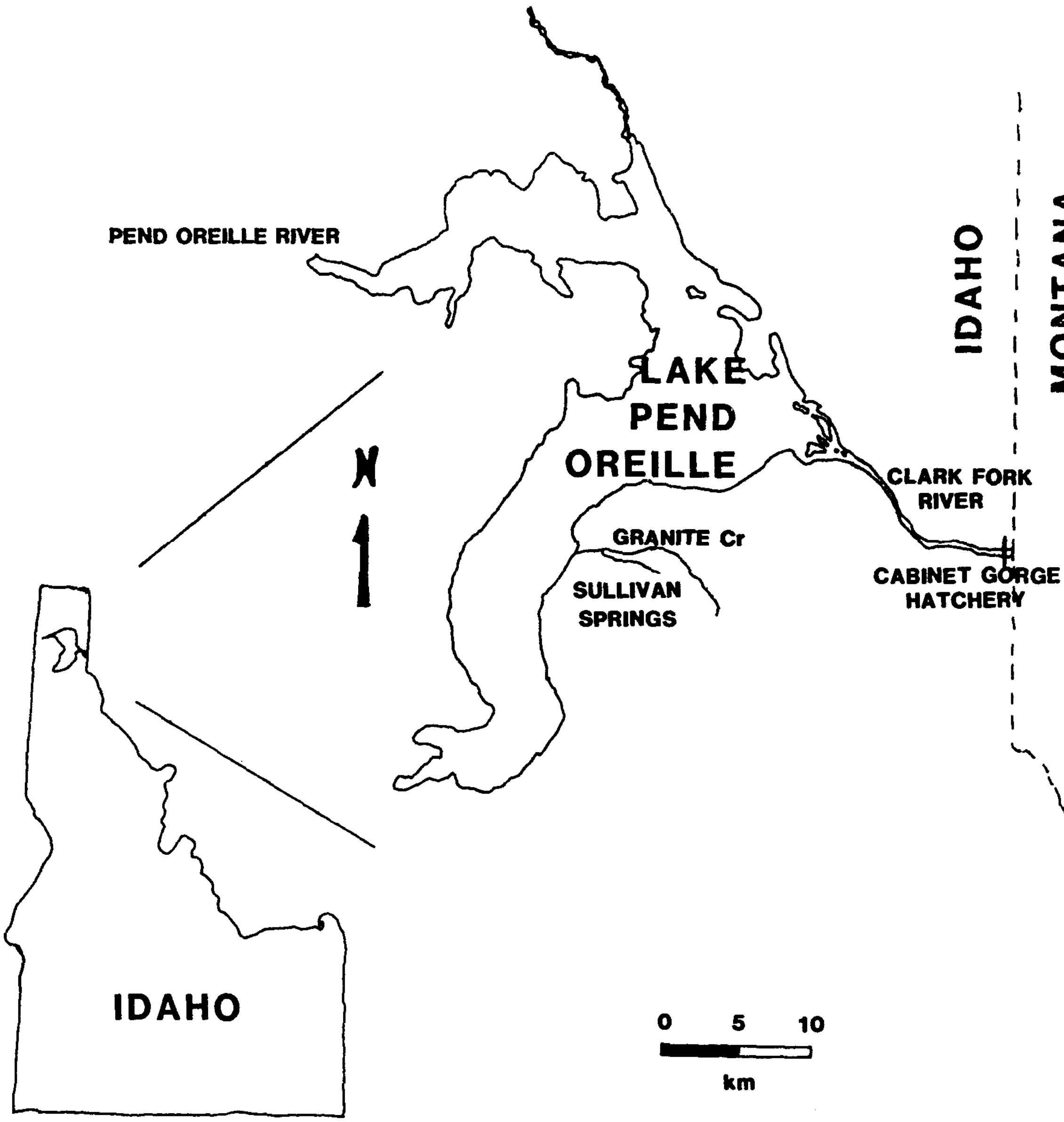

Figure 1. Map of Lake Pend Oreille, Idaho.

Lake Pend Oreille is a temperate, oligotrophic lake. Summer temperatures average approximately 9°C in the upper 45 m (Rieman 1977). Thermal stratification typically occurs from late June to September. The N:P ratio is typically high (>11) and indicates primary production may be P limited (Rieman and Bowler 1980). Mean chlorophyll "a" concentration during summer is approximately 2 micrograms/1. Summer mean water transparency (Secchi disk) ranges from 5 to 11 m.

A wide diversity of fish species are present in Lake Pend Oreille. Kokanee entered the lake in the early 1930s, presumably from Flathead Lake, and were well established by the 1940s. Other game fish include: Kamloops (Gerrard) rainbow trout, bull trout, rainbow trout Salmo gairdneri, westslope cutthroat trout Salmo clarki lewisi, lake whitefish Coregonus culpeaformis, mountain whitefish Prosopium williamsoni and several spiny ray species.

METHODS

Kokanee Abundance

Kokanee were sampled the last week in August with a midwater trawl towed by a 8.5 m boat powered by a 140 hp diesel engine. The trawl net was 13.7 m long with a 3 x 3 m mouth. Mesh sizes (stretch measure) graduated from 32, 25, 19 and 13 mm in the body of the net to 6 mm in the cod end. All age classes of kokanee were collected. Trawling was done at night during the dark phase of the moon to optimize capture efficiency (Bowler 1979). The trawl was towed at 1.5 m/second at depths calibrated with sonar. Each oblique haul sampled the entire vertical distribution of kokanee, as determined from echograms produced by a Ross 200 angstrom depth sounder with two hull-mounted transducers (22° and 8° beam angles). The vertical distribution of kokanee was divided into 3.5 m layers; usually 3 to 5 layers encompassed the vertical distribution of kokanee. A standard 3.5 minute tow was made in each layer, sampling 2,832 m^3 of water over a distance of 305 m. Total volume of water sampled for each trawl haul varied from 8,496 to 14,160 m^3, depending on the vertical distribution of kokanee.

A stratified systematic sampling scheme was used to estimate kokanee abundance and density. Lake Pend Oreille was divided into six sections or strata (Figure 2). The area of each section was calculated for the 91.5 m contour; however, Section 6 was calculated from the 36.6 m contour in the northern end because of shallower water. The 91.5 m contour was used because it represents the pelagic area of the lake where kokanee are found during late summer (Bowler 1978). Six transects were systematically selected within each section, and one haul (sample) was made along each transect. Total sample size in 1987 was 36 hauls.

Fish numbers/transect (haul) were weighted by transect volume and the age-specific and total number of kokanee for each stratum and lake total were calculated using standard expansion formulae for stratified sampling designs (Scheaffer et al. 1979). Kokanee population estimates (total and

Section	Area (hectares)
1	3,166
2	3,220
3	3,739
4	4,036
5	3,373
6	5,011

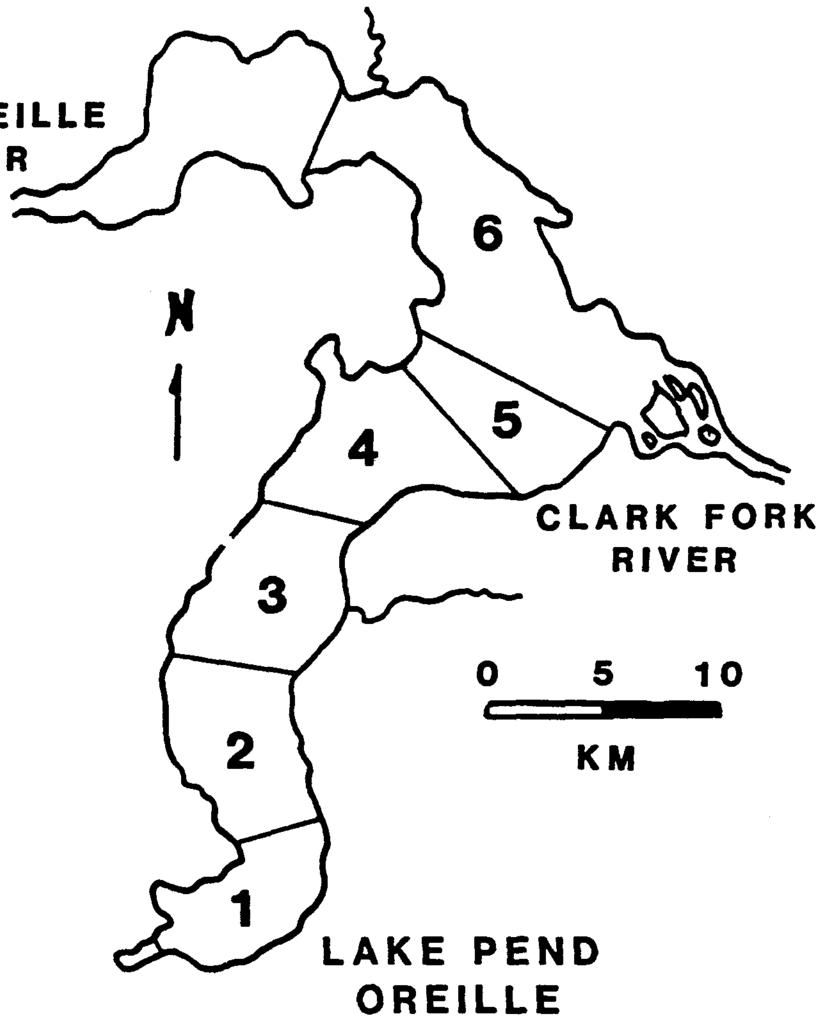

Figure 2. Stratified sampling sections and respective areas (hectares) used during 1987 for trawling and kokanee abundance estimation on Lake Pend Oreille, Idaho.

by section) were divided by respective lake surface areas to calculate kokanee densities (number/hectare) for each age class. Confidence intervals (90X) were calculated to compare estimates among age classes, lake sections and years.

Survival

Relative recruitment and survival of hatchery-reared fry were determined from trawl catches of marked fry. Approximately 6 million fry were released into Lake Pend Oreille tributaries during July 1987 (Table 1). Fifty-five percent were released from Cabinet Gorge Hatchery into the Clark Fork River. The remaining 452 were trucked from Cabinet Gorge and Clark Fork hatcheries to Sullivan Springs Creek (Figure 1). Tetracycline-marked fry have been released into Lake Pend Oreille and its tributaries since 1978 (Appendix A). In 1987, all hatchery fry were marked with tetracycline prior to release. Tetracycline (TM-50) was mixed with fish feed at the rate of 112 by weight and fed to kokanee fry for 10 days prior to release. Kokanee fry captured in the trawl during late August were examined for tetracycline marks with a longwave (3,600 angstrom) ultraviolet light. When exposed to ultraviolet light, a yellow sheen is observed around the mandibles, opercles and bases of pelvic and pectoral fins. This mark is visible for several months after release. Survival of hatchery-reared kokanee fry was determined by comparing estimates of tetracycline-marked fry in the lake during August to known numbers of marked fry released earlier in the year.

Recruitment and survival of hatchery-reared fry were differentiated between release sites by analyzing daily growth ring patterns on otoliths excised from fry collected during August trawling. Otoliths were embedded, ground and observed at 1000 power with an oil immersion compound microscope equipped with a video camera and black and white monitor. The release dates were evident as an obvious mark on the otoliths because daily growth rings were twice as wide during hatchery residence than lake residence. Release date, and thus release site, was determined by enumerating daily growth rings between the release mark and otolith margin.

Wild fry survival from potential egg deposition (PED) to September abundance was estimated from trawl catches. PED was calculated by multiplying average fecundity by estimated mature female kokanee abundance.

Annual survival was estimated for age 1+ and older kokanee by comparing trawl-estimated abundance for each year class between years. Relative distribution of kokanee age classes was determined from abundance estimates for trawl catches within each section.

Emigration rates and relative survival of kokanee fry emigrating from Cabinet Gorge Hatchery to Lake Pend Oreille (22 km) were estimated during two discharge regimes from Cabinet Gorge Dam. Fry were released from the hatchery at dusk (2100 hours) approximately one hour prior to flow manipulation by WWP. Approximately 2.5 million fry were released into the

Table 1. Hatchery-reared kokanee fry released into Lake Pend Oreille, Idaho, during 1987.

Release site	Rearing hatchery	Release date	Number released
Clark Fork River	Cabinet Gorge	July 22	2,777,662
		July 27	236,043
		Total	3,013,705
Sullivan Springs	Cabinet Gorge	July 7	607,825
		July 9	693,940
		July 15	644,653
		Subtotal	1,946,418
	Clark Fork	July 14	260,373
		July 16	516,451
		July 29	124,103
		Subtotal	900,927
		Total	2,847,345
		Grand Total	5,861,050

Clark Fork River on July 22 and 0.18 million on July 27. WWP provided 20,000 cfs flows for two nights (5 h pulse/night) following the first release. Flows during the second release were 22,000 cfs for the first two hours of the night and 16,000 cfs for the last four hours. Dam discharge records were provided by WWP. We verified and calibrated these flows on site with a General Oceanics velocity meter.

Fry emigrants were sampled with a series of eight drift nets suspended from a bridge near Clark Fork, Idaho, approximately 20 km below the hatchery. The nets were 3 m long with a 1 m diameter round mouth which tapered to a 102 mm diameter detachable bucket (PVC). Mesh sizes (stretch measure) graduated from 6.4 mm near the hoop to 3.2 mm in the cod end.

Nets were suspended from the bridge with a cable and pulley system and held in position with a 32 kg section of iron rail. Nets were set and pulled using a truck-mounted pivoting boom and 1.6 hp electric-powered winch. The cable and pulley system allowed nets to be positioned at various depths and the weights to remain stationary on the river bottom during retrieval.

We used a temporally stratified, systematic sampling scheme to collect kokanee fry and estimate relative survival and emigration rates. Nets were evenly spaced across the river channel (262 m wide) and checked every 1 to 3 h throughout the night. Mean depth of the channel at the sampling station was approximately 2 m. Emigration rates were calculated by dividing the distance traveled (20 km) by the time required to travel. Survival was measured by comparing estimated abundance of emigrating fry at the netting site (near the mouth of Clark Fork River) to known numbers of fry released at Cabinet Gorge Hatchery. Fry abundance was estimated by calculating the mean total catch/net/night (corrected for efficiency) and expanding the estimate to represent the entire river cross section. Estimates of survival and emigration rates were compared as a function of Clark Fork River flows for both release groups.

Sampling efficiencies were estimated during each flow regime. Approximately 50,000 fry were released the first night of each test 500 m upstream from the sampling site. Fry were distributed evenly across the river during release. These fry had been marked previously with orange fluorescent grit and held for at least 7 d before release to negate marking related stress and mortality. Sampling efficiency associated with each flow was calculated as the estimated proportion of released grit-marked fry reaching the downriver sampling site and assumes mortality of fry between release and sampling points was negligible.

Fry mortality associated with the release system plumbing from Cabinet Gorge Hatchery to the fish ladder was evaluated by comparing relative survival of fish passed through the system to fish released directly into the ladder. Approximately 100,000 fry were marked with Bismark Brown fluorescent dye by immersing them for 1 h in a solution of 1 part dye to 30,000 parts water by weight. Marked fry were released directly into the fish ladder on the Clark Fork River at the same time 2.5 million fry were released from the hatchery to the ladder via the release system plumbing. Fry were sampled with drift nets located downstream as discussed previously and relative survival compared between the two release methods.

Fry Marking

Several marks were tested during 1986 and 1987 for retention and associated fry survival to determine the feasibility of differentially marking kokanee fry to test success of various release strategies once fish had entered Lake Pend Oreille. Marks evaluated during 1986 included tetracycline, fluorescent dye and three applications of fluorescent grit. During 1987, we completed evaluations of fluorescent grit marks and also evaluated pigmented feed and otolith coding as potential marks.

The fluorescent grit marks were applied by spraying granular (30 to 350 microns) pigment into the dermis layer of fry with compressed air. During 1987, grit was applied to fry at four rates: 50 lb/in from 15 cm, 70 lb/in^2 from 30 cm, 80 lb/in^2 from 15 cm and 80 lb/in^2 from 30 cm. Fish length at marking averaged 50 mm. Initial marking mortalities and retention were evaluated for one week by comparing to an unmarked control group. The application procedure that resulted in acceptable mark retention (>90%) and lowest initial marking mortality was used to mark four additional replicate groups of fry (:7.0 fry/group), which averaged 57 mm total length (TL) and 655 fry/kg. Each replicate group was held in a separate net pen constructed of 3 mm hardware cloth and placed in a raceway at Cabinet Gorge Hatchery. Fry survival was monitored daily for the first week following mark application and then weekly thereafter. A black light (ultraviolet) was used to determine mark retention from a weekly subsample of at least 10 fry from each replicate group. The study was designed to evaluate the fluorescent grit mark for 10 consecutive weeks, but was ended after only two weeks because of an unanticipated dewatering of the raceway and subsequent mortality of fry.

Pigmented feed was used to determine if fry flesh could be artificially colored to differentiate fry releases. Pigment (Carphyl Red) was mixed with feed at a rate of one part pigment to 2,000 parts feed by weight and fed to fry three times/day at typical feeding rates for nine consecutive weeks. Average fry length ranged from 41 mm at the beginning of the study to 52 mm at the end. Subsamples of 10 fry from each of four replicate groups were collected midway and at the end of the study and examined for visible evidence of red pigment.

Water temperature manipulations and time-of-release were used to determine if kokanee fry otoliths could be coded to differentiate fry releases. Coding otoliths through water temperature manipulations at the hatchery prior to fry release in 1987 will be evaluated in 1988. Differentiating fry releases by analyzing otoliths for release date was evaluated in 1987.

Zooplankton

The zooplankton community was sampled in the southern, central, northern and Clark Fork River delta portions of Lake Pend Oreille (Figure 3). Five random samples were collected monthly from each section from May through October in the main body of the lake and from June through September in the delta section. Samples in the main body of the

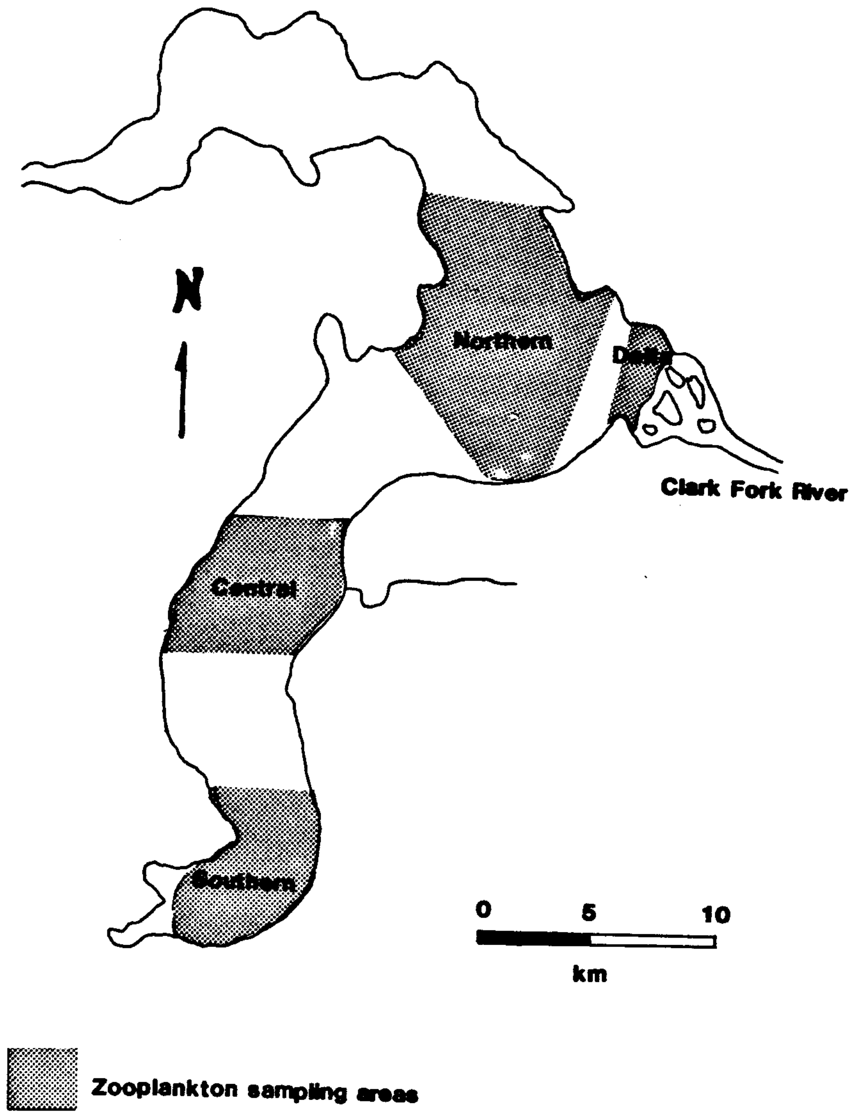

Figure 3. Zooplankton sampling areas on Lake Pend Oreille, Idaho.

lake were collected with a 0.5 m diameter ring plankton sampler calibrated by a General Oceanics flow meter and equipped with a 130 micron net and bucket. Vertical hauls from 27.4 m depths to the surface were made by raising the sampler approximately 0.5 m/s with an electric winch. Samples from the shallower delta section were collected with a Miller high-speed plankton sampler equipped with a flow meter and 130 micron net and bucket. In the delta, the entire water column was sampled with oblique tows stepped at 1.5 m intervals. The sampler was towed at 1.5 m/s for a minimum of 40 s/sample. Zooplankters were enumerated by genus using standard dilution and subsampling methods (Edmondson and Winberg 1971). Enumeration data were standardized by volume of water filtered to determine zooplankton densities. Up to 50 organisms/genus/sample were measured by projecting their image on a calibrated screen. Mean lengths were calculated for each month and lake section. Analysis of variance, utilizing a stratified random sampling scheme, was used to compare zooplankton densities and lengths both spatially and temporally.

Mysid Shrimp

Mysis were sampled at night during the dark moon phase in late May. Five samples were randomly collected in each of the three main-lake sections designated for zooplankton sampling (Figure 3). Samples were collected with a Miller high-speed sampler equipped with a General Oceanics flow meter and a 130 micron plankton net and bucket. Stepped oblique tows were made from 46 m to the surface, sampling for 10 s at each 3 m interval. The sampler was towed approximately 1.5 m/s and raised 0.5 m/s with an electric winch. *Mysis* from each sample were counted and differentiated by age class (juvenile or adult). Density estimates were based on volume of water filtered and comparisons made between age classes and among lake sections.

Water Temperature and Transparency

Thermal stratification of Lake Pend Oreille was monitored by measuring water temperature monthly from May through October at one site in the southern section of the lake. Instantaneous temperatures were measured with a probe from the surface to 50 m depths at 1 m intervals for the first 5 m and at 5 m intervals thereafter. Water transparencies were monitored temporally and spatially. A Secchi disk reading was taken in the southern, central and northern sections of Lake Pend Oreille each month from May through October.

RESULTS

Kokanee Abundance, Distribution and Biomass

Estimated total kokanee abundance during late August, 1987, was 6.01 million fish (Figure 4). Contribution of individual year classes was 3.55 million for the 1986 year class (age 0+), 0.78 million for the 1985 year class (age 1+), 0.84 million for the 1984 year class (age 2+), 0.43 million for the 1983 year class (age 3+) and 0.42 million for the 1982 year class (age 4+).

Estimated average kokanee density for the entire lake (all age classes combined) was 266 fish/hectare (Figure 5; Appendix B). Densities ranged from a high of 456 kokanee/hectare in Section 3 to a low of 129 kokanee/hectare in Section 6. Age 0+ wild kokanee densities were highest in southern and central sections of Lake Pend Oreille, whereas hatchery fry densities were highest in the northern sections of the lake. Densities of age 1+ kokanee were significantly ($P<0.10$) higher in central Lake Pend Oreille than other sections. In general, age 2+ and older kokanee densities were highest in the southern end and northern half of Lake Pend Oreille.

Estimated biomass of age 1+ and older kokanee in Lake Pend Oreille during late August was 181,585 kg (8.04 kg/hectare). Mean kokanee lengths and weights from the August trawl catch were 128 mm and 14 g for the 1985 year class (age 1+), 206 mm and 69 g for the 1984 year class (age 2+), 252 mm and 118 g for the 1983 year class (age 3+) and 262 mm and 150 g for 1982 year class (age 4+). Length frequencies of kokanee caught in the trawl are shown in Figure 6.

Spawning Escapement and Potential Egg Deposition

The 1987 spawning population estimate of 574,500 kokanee was derived from August trawling data. Estimated abundance of mature female kokanee was 283,600 fish (49X). Based on an average fecundity of 410 viable eggs/female (Gene McPherson, IDFG, unpublished data), estimated potential egg deposition for Lake Pend Oreille kokanee was 116.3 million eggs. Age composition of mature kokanee was 212 age 3+ and 79% age 4+. An estimated 39% of age 3+ kokanee were mature and consisted of 472 males and 53% females. Approximately 97% of age 4+ kokanee were mature and consisted of 522 males and 482 females.

Egg-taking operations at the weir on Sullivan Springs Creek began the first week of November and will continue through early January 1988. Additional eggs will be collected from kokanee spawners in the Clark Fork River and Lake Coeur d'Alene.

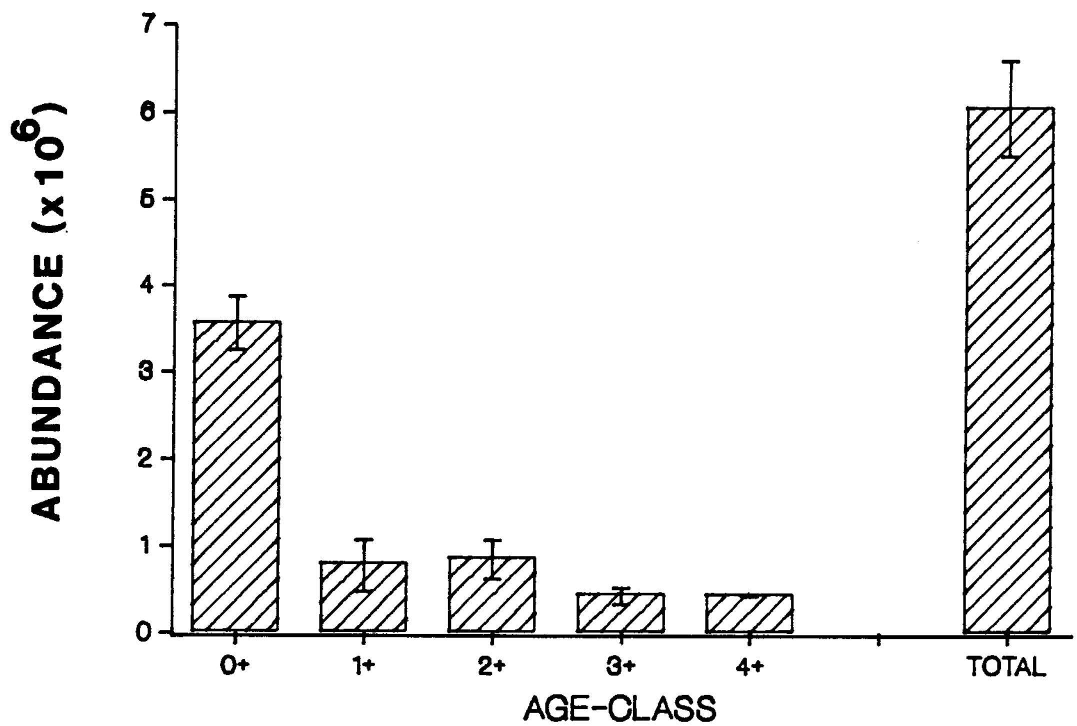

Figure 4. Estimated kokanee abundance, with 90% confidence intervals, for late August, 1987, Lake Pend Oreille, Idaho.

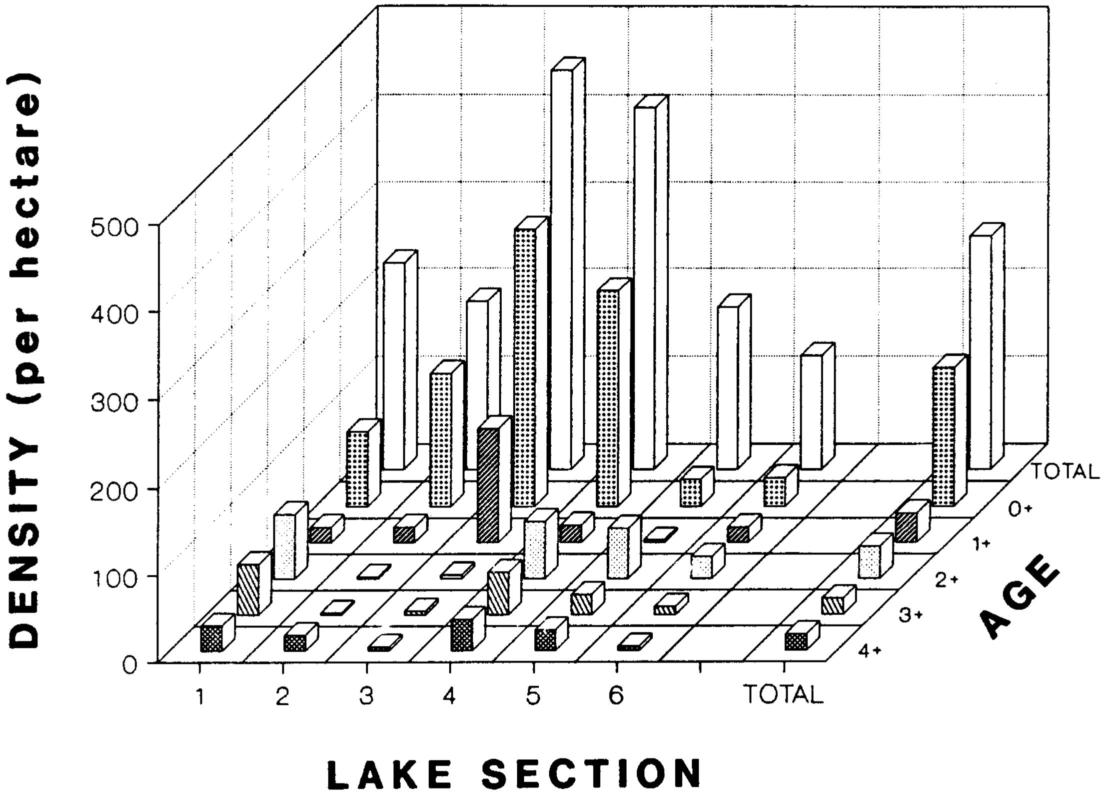

Figure 5. Kokanee density in Lake Pend Oreille, Idaho, by age class and lake section during late August, 1987.

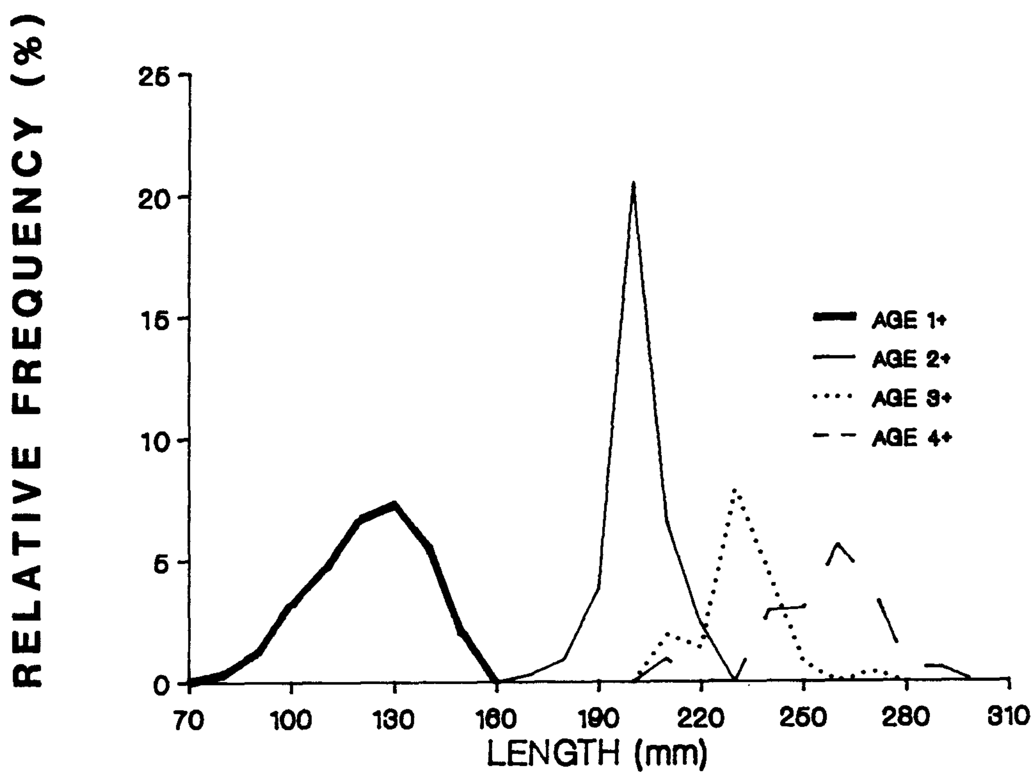

Figure 6. Length frequency of kokanee, by age class, in Lake Pend Oreille, Idaho, during late August, 1987.

Fry Emigration

Survival of hatchery-reared kokanee fry emigrating from Cabinet Gorge Hatchery to Lake Pend Oreille was higher when Clark Fork River flows were pulsed upward shortly after release than when flows declined shortly after fry release (Figure 7). Fry were 5 times more likely to reach the river delta when nighttime flows were increased from 7,000 to 20,000 ft^3/s within 2 h after fry release than when nighttime flows declined from 22,000 to 16,000 ft^3/s within 3 h after fry release. Efficiency of sampling kokanee fry in the Clark Fork River was 13% during 20,000 ft^3/s flow and 39% during 16,000 ft^3/s flow.

Estimated total kokanee fry survival (with 90% CI) from Cabinet Gorge Hatchery to the Clark Fork River delta was 31% ± 11%. Over 93% of fry released into the Clark Fork River were released during the first flow regime. Estimated emigration survival during the first release (flow increased from 7,000 to 20,000 ft^3/s) was 33% ± 12%. Fry survival associated with the second flow regime (flow declined from 22,000 to 16,000 ft^3/s) was 6.9% ± 3.9%.

Emigration rates were similar for each flow test (Figure 7). During the first flow regime, 78% of the fry reaching the river delta emigrated at a minimum rate of 5.0 km/h and 95% of the surviving fry reached the delta during the first night. During the second flow regime, 75% of the fry maintained a minimum emigration rate of 5.7 km/h and 98% of the surviving fry reached the rive: delta the first night.

Fry survival associated with the hatchery release system, which routes fry through a plumbing network to a fish ladder on the Clark Fork River, was not significantly ($P>0.10$) lower than survival of fry trucked around the release plumbing and released directly into the fish ladder. Survival rate from time of release to sampling near the Clark Fork River delta was 37% for trucked fish compared to 33% for fish routed through the hatchery release plumbing.

Survival and Recruitment

Estimated kokanee fry survival from potential egg deposition to August trawl sampling was 5.2% for the 1986 year class. Survival estimates for hatchery and wild fry were 8.9% and 4.6%, respectively. A survival rate of 14% was estimated for 1986 year class hatchery-reared fry from time of release in mid-July to fall sampling in late August. Fry released into the Clark Fork River had significantly lower ($P<0.10$) survival (9.7%) from time of release to trawling than fry released into Sullivan Springs Creek (18%).

Hatchery fry provided an estimated 22% of the total kokanee fry recruitment in 1987. Fry released into Sullivan Springs made up 63% of total hatchery fry recruitment in Lake Pend Oreille, whereas fry released into Clark Fork River made up 37% (Figure 8). Although dispersal of

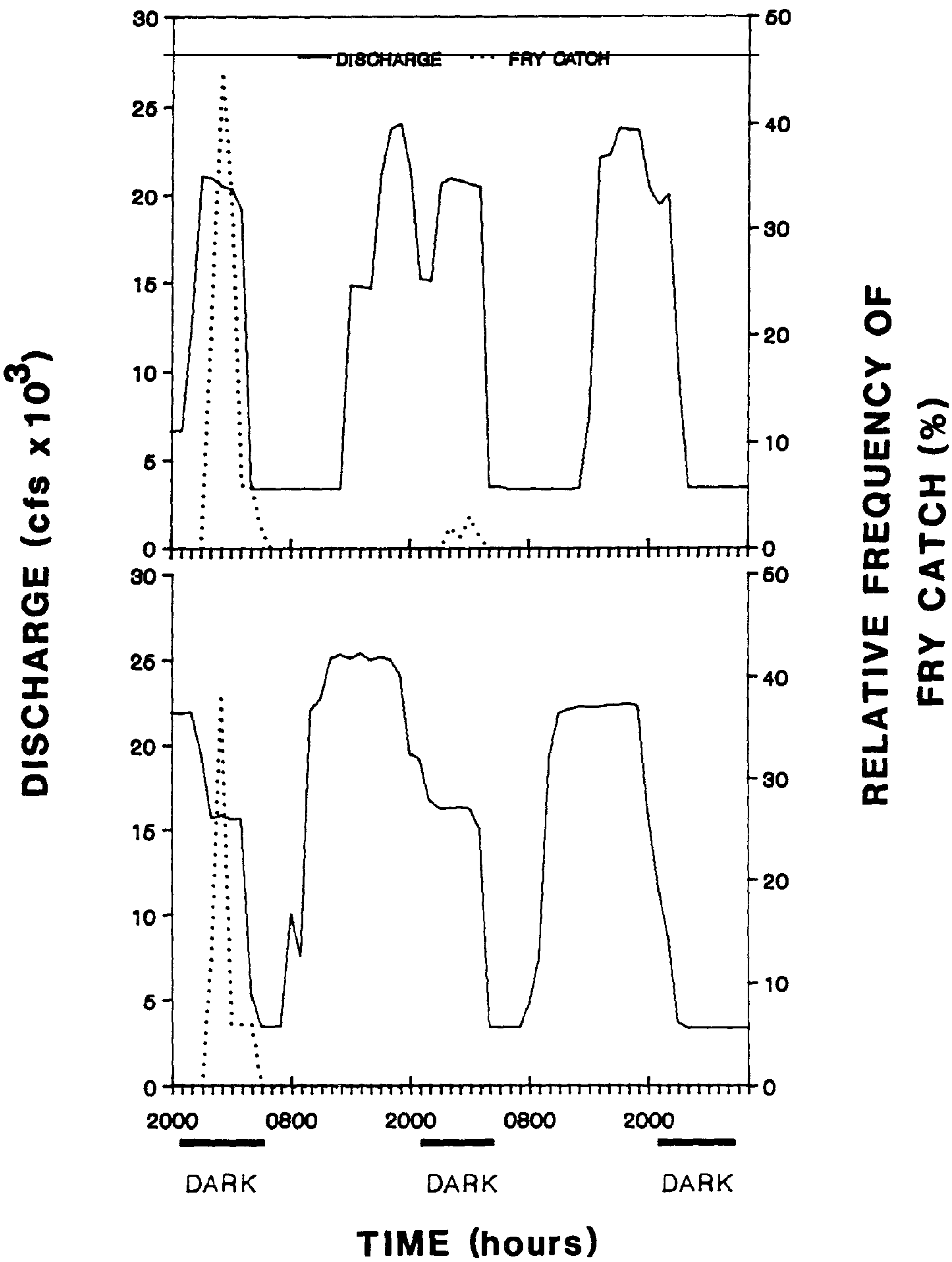

Figure 7. Discharge from Cabinet Gorge Dam into Clark Fork River and frequency of fry caught 20 km downstream during three nights following each fry release (at 2100 hours) from Cabinet Gorge Hatchery.

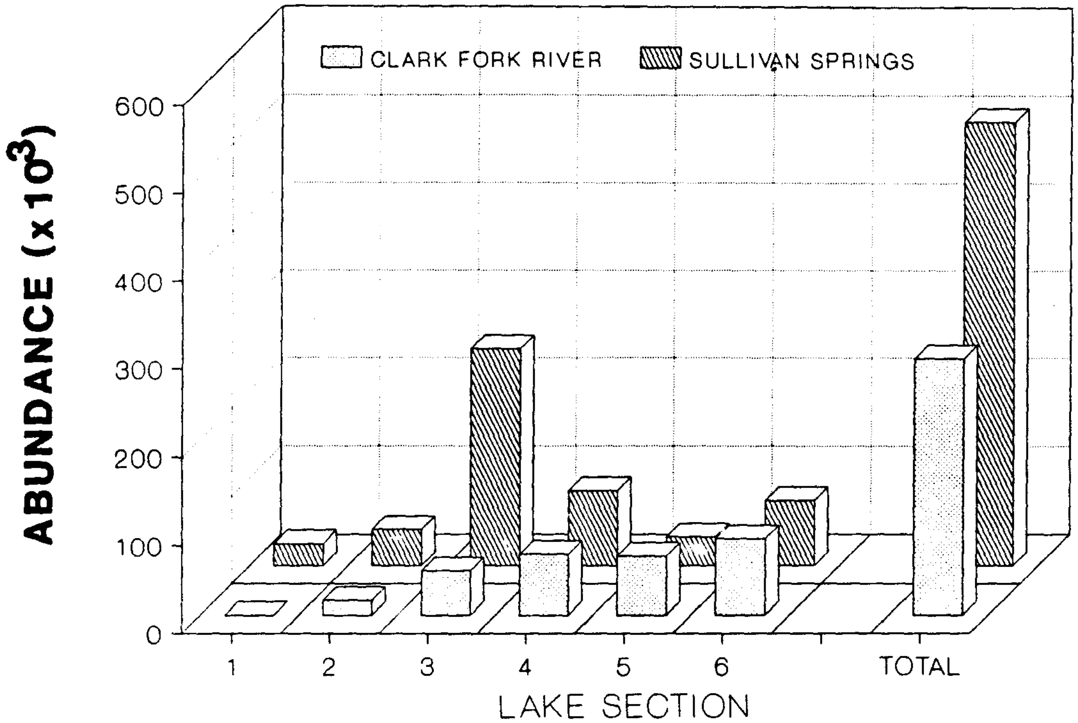

Figure 8. Abundance and distribution of hatchery-reared kokanee fry released into Clark Fork River and Sullivan Springs Creek in mid-July and collected late August from Lake Pend Oreille, Idaho.

hatchery-reared fry throughout the lake was evident following one month of lake residence, abundance remained highest in lake sections near release sites. Estimated annual survival (late summer to late summer for wild and hatchery fish combined) of other immature kokanee was 47% for the 1985 year class (age 1+), 73% for the 1984 year class (age 2+), 63% for the 1983 year class (age 3+) and 93% for the 1982 year class (age 4+).

Fry Marking Study

Fluorescent Grit

Kokanee fry (51 mm TL) were marked with four application rates of fluorescent grit to test mark retention and associated mortality (Table 2). Initial (1 d) marking mortalities ranged from 74% when grit was applied at 80 lb/in^2 15 cm from the fry to 7% when applied at 70 lb/in^2 30 cm from *fry.* Over 95% of all mortalities occurred within 1 d of treatment. No mortalities were observed in an unmarked control group. Mark retention through 1 week was 100% for all treatments.

Larger kokanee fry (57 mm TL, 655 fry/kg) were marked with fluorescent grit at 70 lb/in^2 30 cm from fry. Initial mortality was less than 3%, with 90% of the mortality occurring within one day of application. Mark retention was 100% through one week.

Pigment

Pigmented feed (Carphyl Red) was fed to kokanee fry in an attempt to color muscle tissue. At an application rate of 1 part pigment to 2,000 parts feed by weight, tissue color remained indistinguishable from an unmarked control group throughout 10 weeks of treatment. Mortality of treated groups did not differ significantly ($P>0.10$) from a control group.

Otolith Coding

Analysis of daily growth rings on kokanee fry otoliths indicated an obvious mark at the time of release, which separated hatchery residence from lake residence (Figure 9). Mean width of daily growth increments was two times larger during hatchery residence than lake residence. Kokanee released on different dates were identified by counting daily growth rings from the time-of-release mark to the otolith margin (time of fall sampling). Approximately 98% of counts (n=59) from the time-of-release mark to the otolith margin fell within the expected number of days from time of release to fall sampling. The remaining 2% were within one day of the expected dates.

Differentiation between Clark Fork River and Sullivan Springs release sites was also possible by examining the actual time-of-release mark. Fry released in the Clark Fork River had a wide, translucent (white) band separating hatchery residence from lake residence (Figure 9). This white band was not observed on otoliths from fry released into Sullivan Springs Creek.

Table 2. Fry mortality and mark retention associated with fluorescent grit (30-350 microns) applied to kokanee fry at various pressures and distances.

Fry length	Application	Distance from	Mortality (%)		Retention (%)	
(mm TL)	pressure (lb/in^2)	fry (cm)	1 Day	1 Week	1 Day	1 Week
50	50	15	10.5	11.0	100	100
50	70	30	7.2	7.2	100	100
50	80	15	74.2	74.6	100	100
50	80	30	14.8	14.8	100	100
57	70	30	2.9	3.5	100	100
50	Control		0	0		

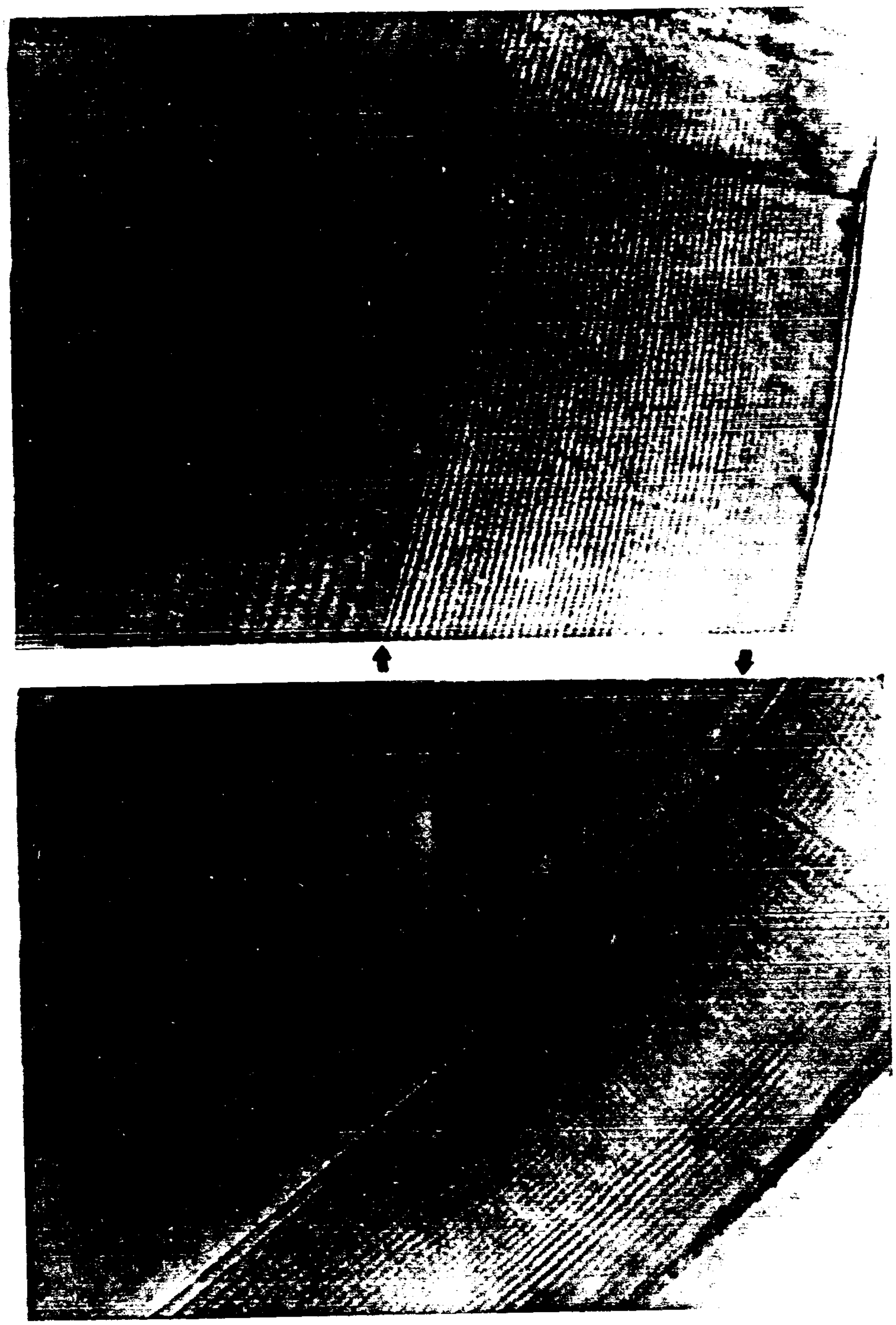

Figure 9. Daily growth increments of sagitta otoliths from hatchery-reared kokanee fry collected in Lake Pend Oreille, Idaho. Arrows indicate time-of-release mark separating hatchery residence (wide bands) from lake residence (narrow bands). Otolith in top photo is from a fry released into Sullivan Springs Creek. Bottom photo shows otolith from a fry released into Clark Fork River.

Mysid Shrimp

Density of Mysis in Lake Pend Oreille during late May 1987 averaged 0.020 organisms/1 (Figure 10). This estimate was significantly lower (P=0.009) than the 1986 estimate (0.039 organisms/1). Total densities in 1987 did not differ significantly (P=0.142) among southern, central and northern lake sections.

Juveniles comprised 80% of total Mysis abundance in Lake Pend Oreille, with an average density of 0.016 organisms/1 (Figure 10). Estimated juvenile density in 1987 was significantly lower (P=0.014) than 1986 (0.031 organisms/1). Juvenile densities in 1987 did not differ significantly (P=0.336) among lake sections.

Adult mysids comprised 20% of total Mysis abundance during late May 1987. Adult density averaged 0.004 organisms/1 and was significantly lower (P=0.006) than estimated density for 1986 (0.008 organisms/1). Adult densities in 1987 were significantly higher (P<0.014) in northern sections of Lake Pend Oreille than central or southern sections.

Zooplankton Community

Generic composition of zooplankton in Lake Pend Oreille from May through October 1987 included Daphnia, Bosmina, Diaphanosoma, Cyclops, Diaptomus and Epischura. Copepod densities were higher than cladoceran densities throughout the sampling period (Figure 11). Cladoceran production peaked in August at approximately 26% of copepod production. Total zooplankton density ranged from approximately 7 organisms/1 in May and October to approximately 18 organisms/1 in August (Figure 12). The copepods Cyclops and Diaptomus were the most abundant zooplankters, with combined densities ranging from approximately 6 organisms/1 in May and October to approximately 14 organisms/1 in July and August. Average densities of these copepods did not vary significantly among the last three years (P)·0.10), although production during June was significantly higher (P<0.10) in 1987 than 1986 and 1985 (Figures 12 and 13, Appendix C). The cladocerans Daphnia and Bosmina were evident in samples taken during June 1987, one to two months ahead of production in 1985 and 1986. Bosmina densities in 1987 were significantly higher (P<0.10) than 1986 as production began earlier in the year, extended later and peaked during August at 1.1 organisms/1. Mean density of Daphnia in 1987 did not differ signi.-cantly (P>0.10) from 1986. Although peak Daphnia density (2.6 organisms/1 in August) in 1987 was less than 50% of the 1986 peak (6.5 organisms/1 in August), production in 1987 began one month earlier and continued one month later. Epischura and Diaphanosoma were rarely found in Lake Pend Oreille until August, when densities were approximately 0.1 and 0.05 organisms/1, respectively. In general, zooplankton densities were similar (P)0.10) among northern, southern and central sections of Lake Pend Oreille (Figure 13, Appendix C). Zooplankton densities in the Clark Fork River delta section were significantly lower (P<0.10) than other lake sections for the most common genera (Cyclops, Diaptomus and Daphnia) and total zooplankton densities (Figure 13, Appendix C).

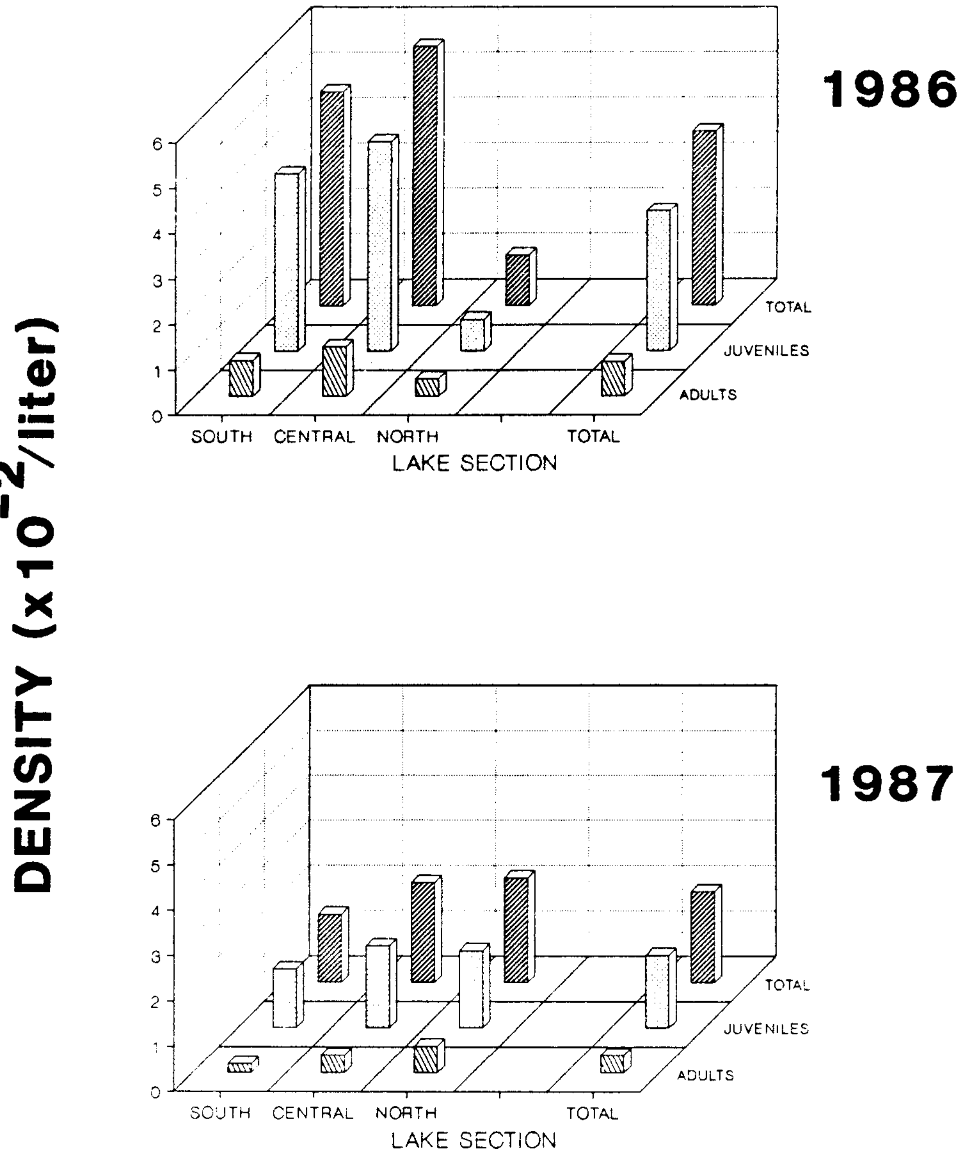

Figure 10. Mean adult, juvenile and total densities of Mysis in Lake Pend Oreille, Idaho, sampled during June of 1986 and 1987.

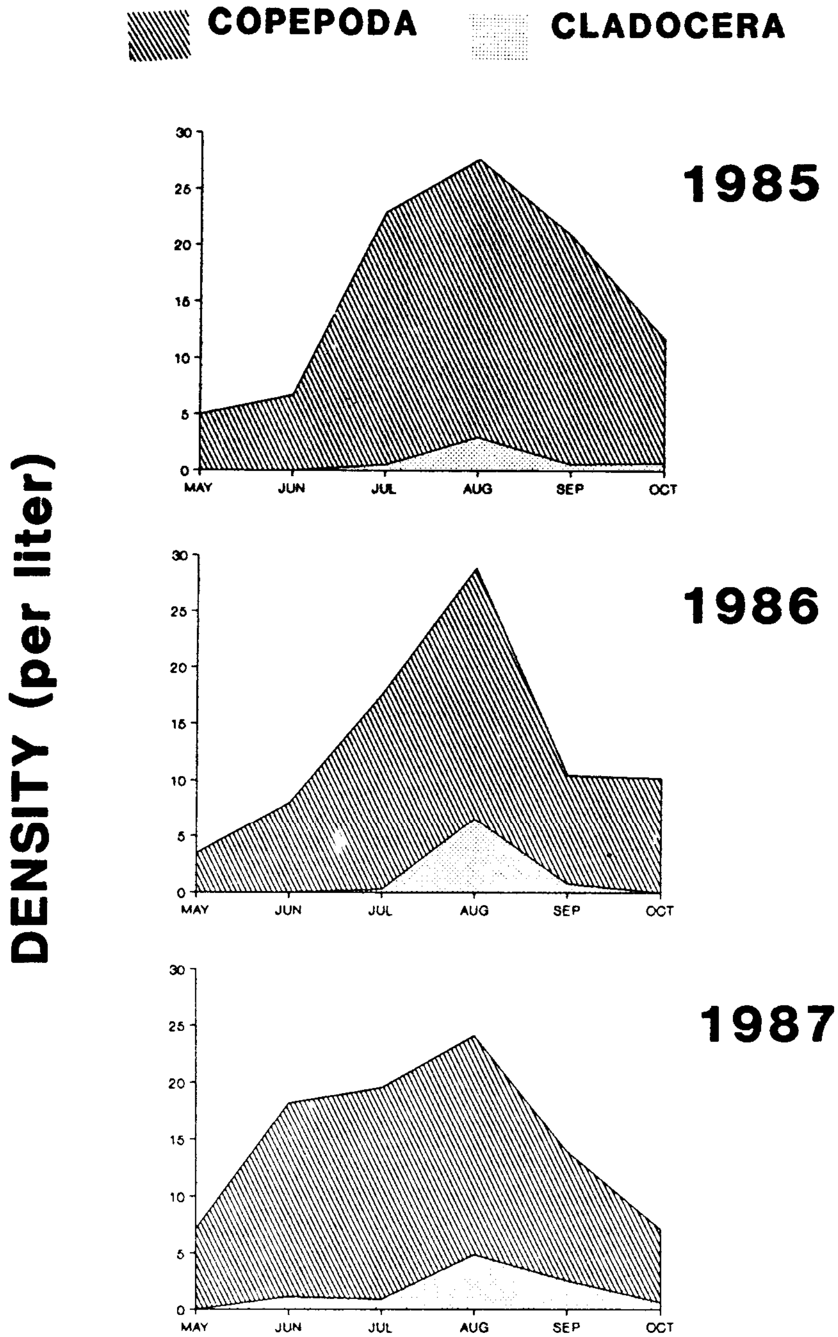

Figure 11. Temporal distribution of Copepoda and Cladocera zooplankton in Lake Pend Oreille, Idaho, May through October, 1985 through 1987.

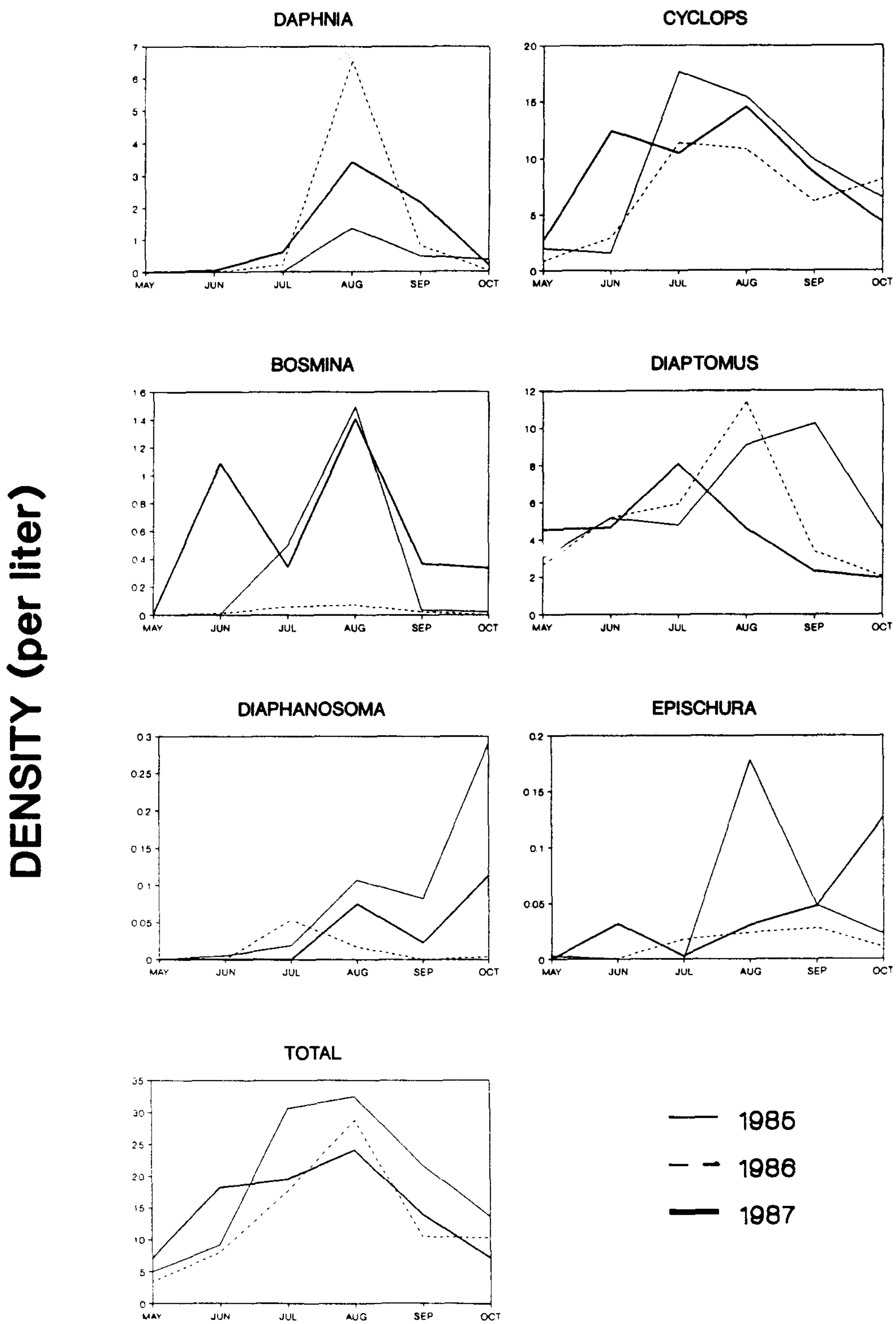

Figure 12. Temporal distribution of mean zooplankton densities in Lake Pend Oreille, Idaho, May through October, 1985 through 1987.

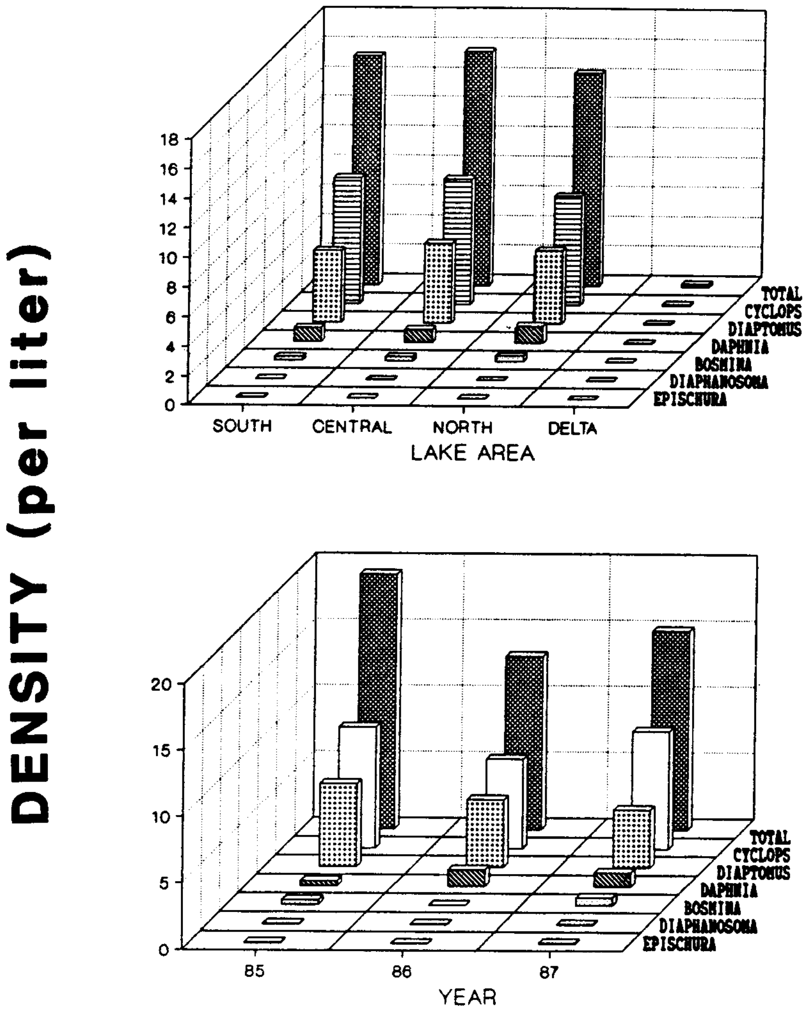

Figure 13. Mean zooplankton densities in Lake Pend Oreille, Idaho, compared among lake sections and years.

The largest zooplankter in Lake Pend Oreille during 1987 was Epischura, which averaged 1.8 mm long, followed by Daphnia thorata and D. galeata, which averaged 1.1 and 1.0 mm, respectively. The size of Diaphanosoma and Diaptomus was similar, 0.95 and 0.91 mm, respectively. Cyclops averaged 0.71 mm long, followed by Bosmina, the smallest zooplankter, at 0.37 mm. In general, zooplankton lengths for each genus did not vary significantly (P>0.10) among the last three years, or among months and lake section (Figures 14 and 15, Appendix C).

Water Temperature and Transparency

Surface temperatures of Lake Pend Oreille from May through October 1987 ranged from 11.6°C in November to 21°C in August (Figure 16). Thermal stratification began in May and extended through October. At peak stratification (August), the thermocline began at a depth of 15 m and average epilimnetic water temperature was 20°C.

Water transparency (Secchi disk) from May through October 1987 ranged from 3.4 m in May to 11 m in September (Figure 17).

DISCUSSION

Kokanee Population Status

Status of the kokanee population in Lake Pend Oreille was encouraging in 1987. Total abundance was 90% higher in 1987 than the previous two years, partially the result of good recruitment of fry released from Cabinet Gorge Hatchery. A dramatic increase in the number of kokanee available for the fishery and spawning escapement was also apparent this year. Age 3+ and 4+ kokanee, which comprise nearly 90% of the fishery (Bowles et al. 1987), were 9X more abundant in 1987 than 1986 and 32% higher than the lowest documented abundance in 1984 (Figure 18). This increase is predominantly the result of a strong 1982 year class (age 4+), which was further strengthened by high survival during the past year (Figure 19, Appendix D). This strong year class (YC) resulted from relatively low fry recruitment in 1983, which indicates year class strength may be determined after the first year of development. The 1982 year class made up 71% of the spawning escapement for Lake Pend Oreille and should provide the highest escapement levels documented since 1982 (Cocanauer 1983). It is important to reiterate that the improvements evident in 1987 are the result of a strong year class and do not indicate a permanent shift in the population size or structure.

The outlook for the fishery and spawning escapement during the next three years is not as encouraging as 1987. In 1988, the combination of a relatively weak 1983 YC (age 3+ in 1987) with a relatively strong 1984 YC (age 2+) will result in a 14% reduction in kokanee available to the fishery. Escapement in 1988 will suffer more than the fishery because

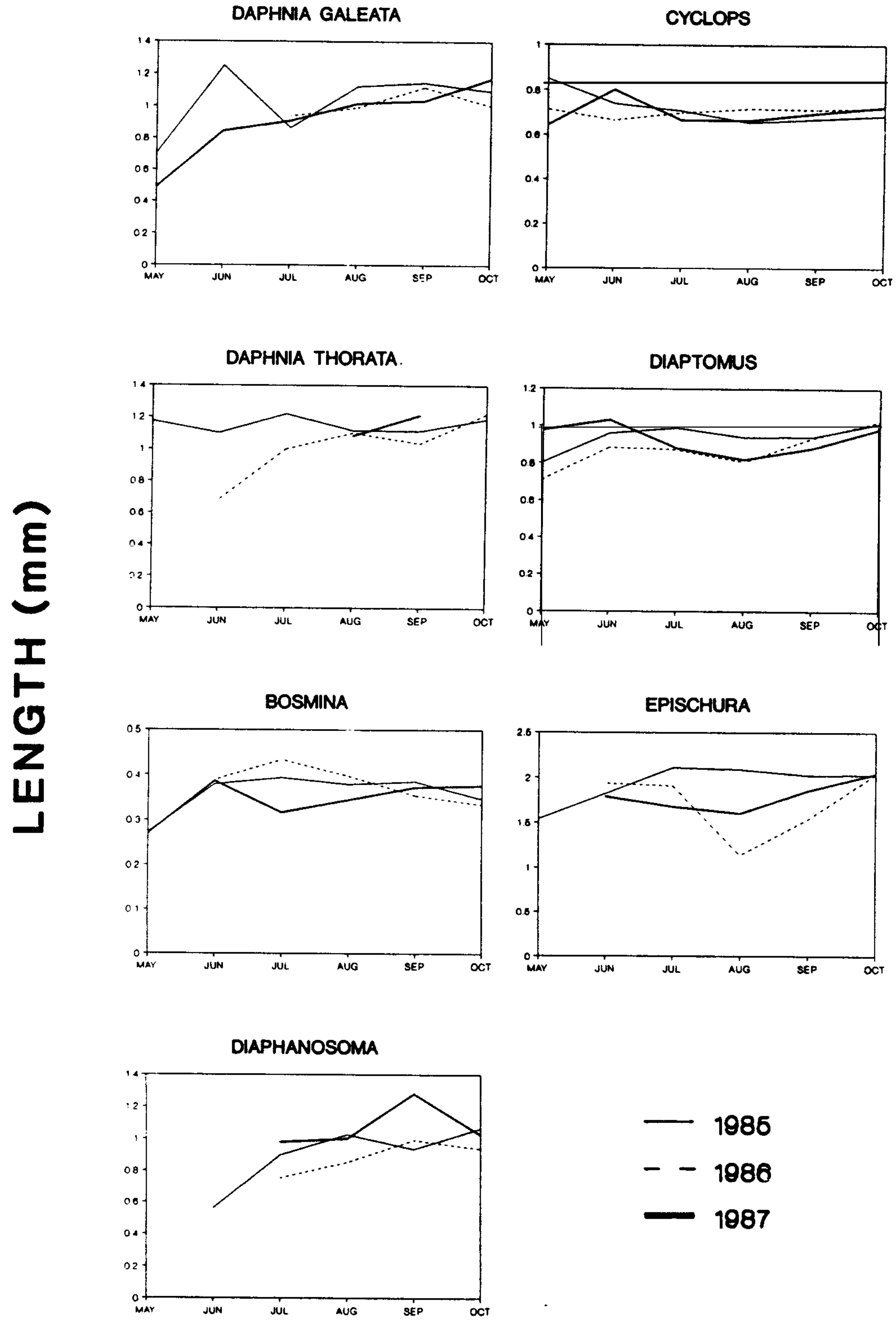

Figure 14. Temporal distribution of mean zooplankton lengths in Lake Pend Oreille, Idaho, May through October, 1985 through 1987.

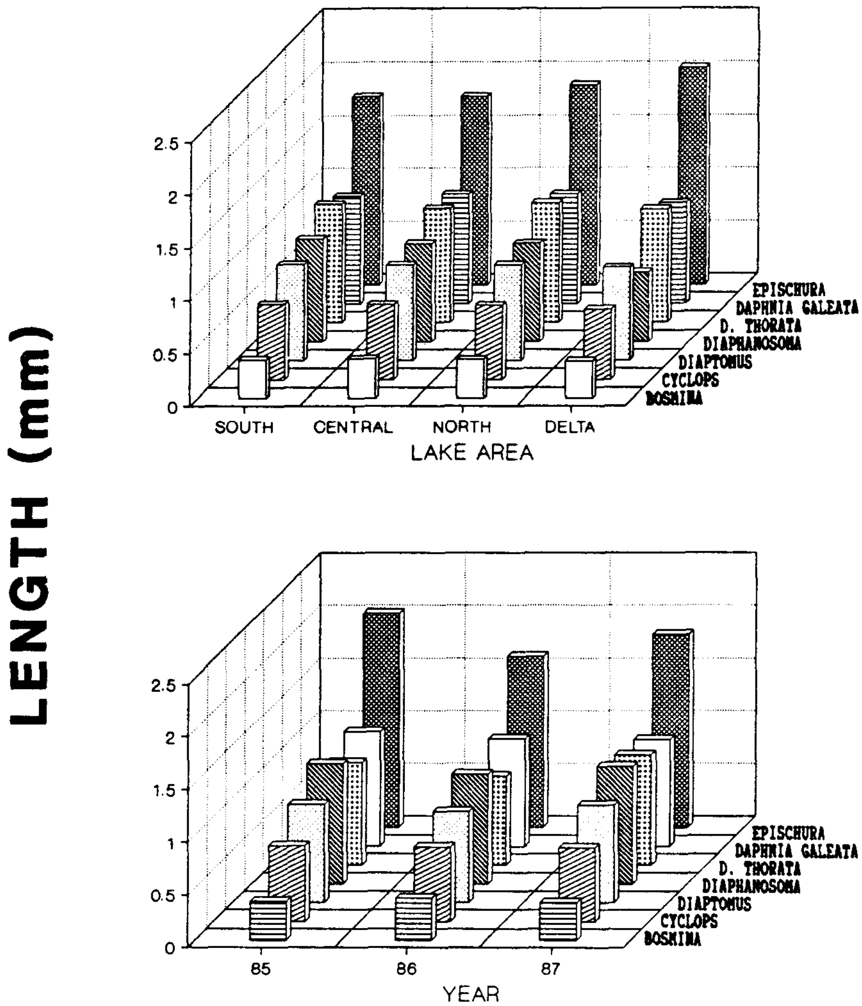

Figure 15. Mean zooplankton lengths in Lake Pend Oreille, Idaho, compared among lake sections and years.

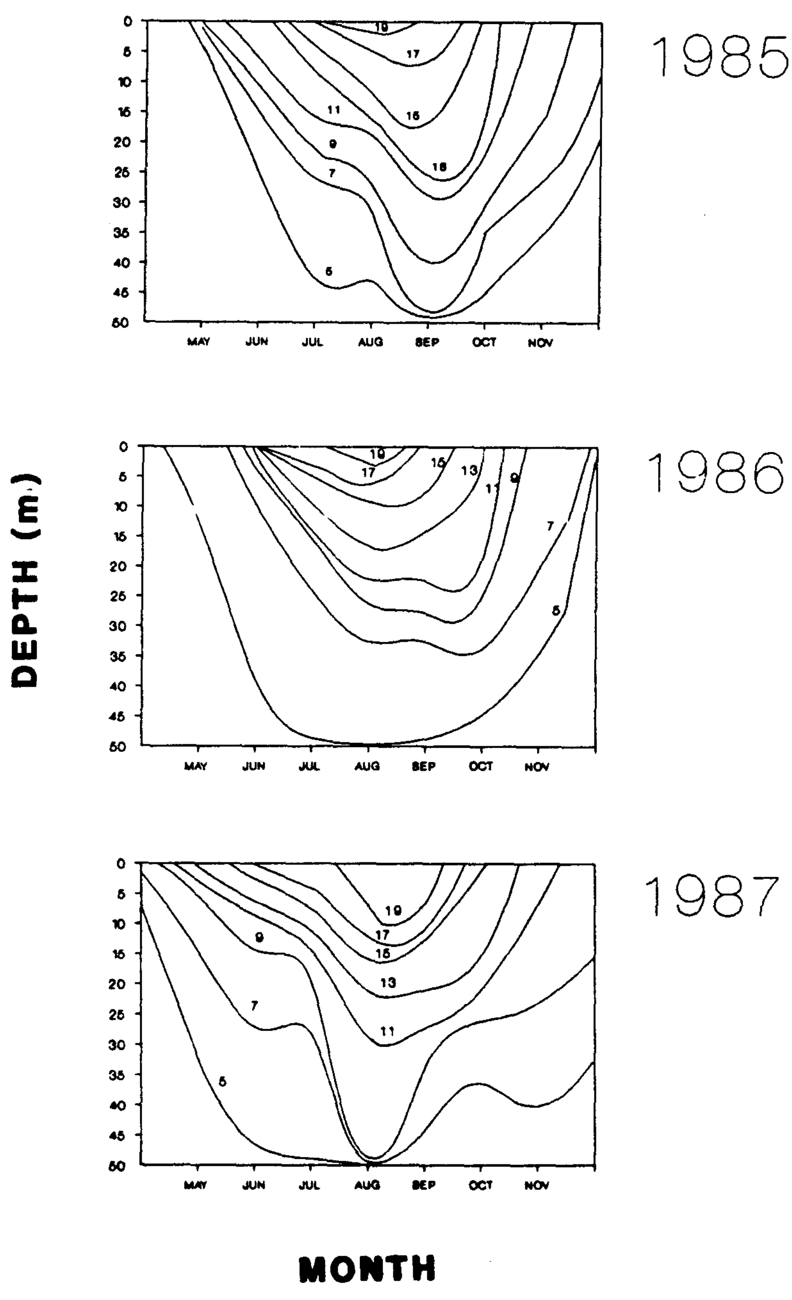

Figure 16. Distribution of thermal isopleths (^{o}C) in the upper 50 m of Lake Pend Oreille, Idaho, May through November, 1985 through 1987.

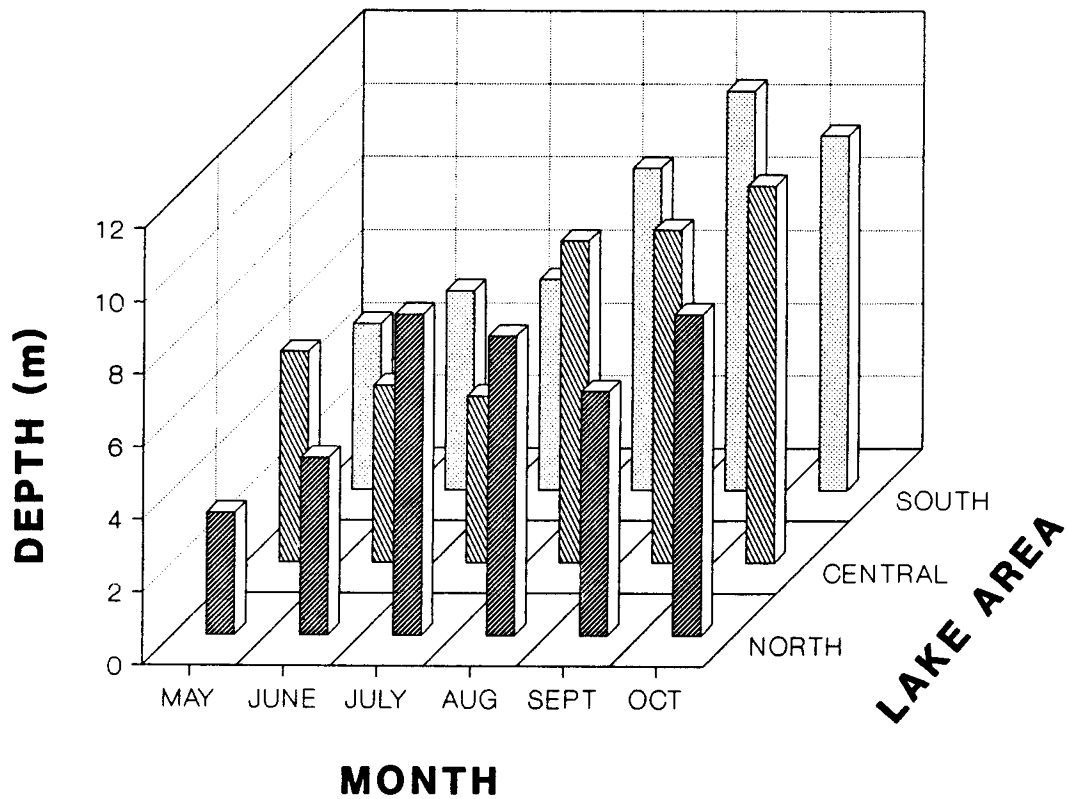

Figure 17. Water transparency (Secchi disk) in three sections of Lake Pend Oreille, Idaho, May through October, 1987.

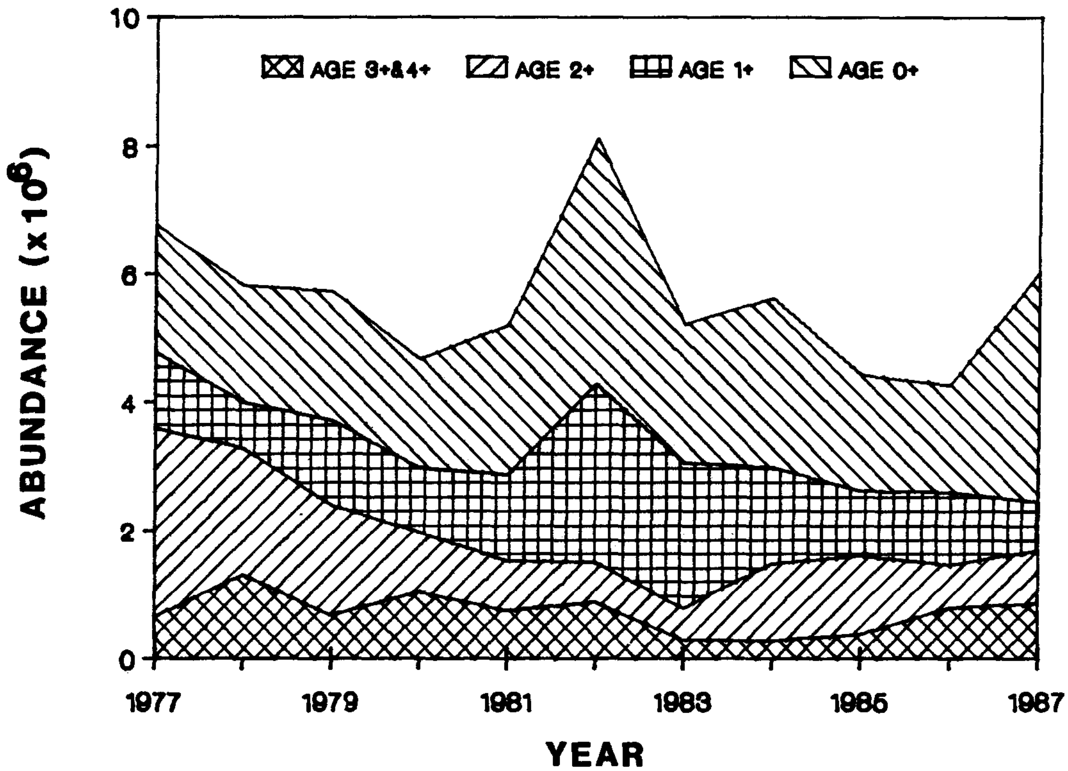

Figure 18. Total estimated abundance of four kokanee age groups in Lake Pend Oreille, Idaho, 1977 through 1987.

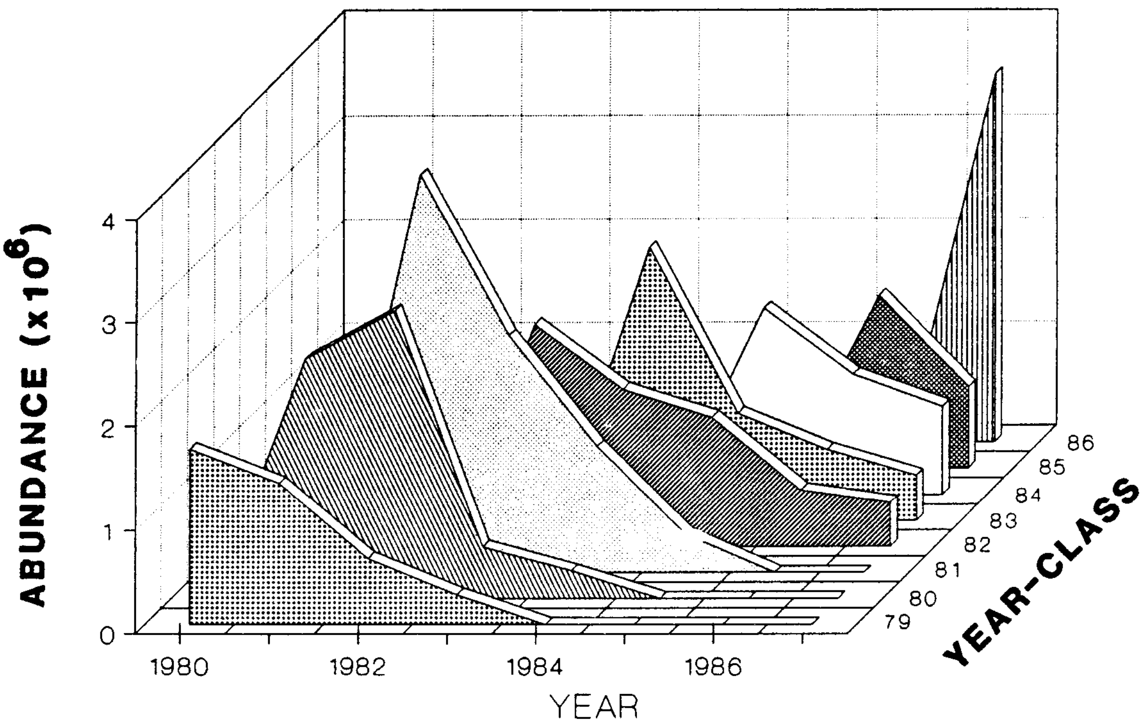

Figure 19. Comparative year class strength of kokanee in Lake Pend Oreille, Idaho, from 1980 through 1987.

only 22% of age 3+ kokanee are mature. The predicted reduction in spawning escapement from 1987 to 1988 could be as great as 43%. This reduction should not be as apparent for escapement to Sullivan Springs because the run is sustained by fry releases.

A very weak 1985 YC (age 1+ in 1987) recruits to the fishery and spawning population in 1989 as age 3+ kokanee. Its impact in 1989 may reduce harvest by 34% and escapement by 57% from 1987 levels. This decline would make 1989 comparable to 1984 escapement and potential harvest levels, which are the lowest documented for Lake Pend Oreille (LaBolle 1986).

The impact of a strong 1986 YC (1987 fry) will become evident by 1990 at age 3+. This strong year class should compensate for a weak 1985 YC and potentially improve the fishery enough to exceed 1987 levels by 23%. Spawning escapement in 1990 could be 35% below 1987 levels, but should increase dramatically in 1991 as the 1986 YC matures.

To meet the program goal of 0.75 million kokanee harvested annually, approximately 3 million age 3+ and older k-kanee are needed in Lake Pend Oreille. Although abundance of these age classes was higher in 1987 (0.85 million) than the previous years, this abundance is only 30% of what is needed to sustain proposed fishery levels. Full production at Cabinet Gorge Hatchery will provide the number and quality of fry necessary to meet this goal.

Fry Recruitment and Survival

Increased fry recruitment from hatchery and/or wild production is prerequisite to rebuilding the kokanee population in Lake Pend Oreille. Recruitment of wild fry almost doubled from 1986 to 1987 and is the highest documented recruitment of wild fry since the mid-1970s (Bowler 1977). This increase was a result of relatively good parental escapement in 1986 and high fry survival resulting from increased zooplankton (forage) availability during early summer. Although wild kokanee typically provide over 75% of total recruitment (Figure 20), conditions regulating wild fry survival are largely uncontrollable. Efforts to rehabilitate the kokanee fishery are thus focused on hatchery production, which requires not only increasing hatchery production levels, but also enhancing survival.

Hatche^r- fry survival and recruitment in 1987 were five times higher than in 1986, which provided the first tangible benefits from Cabinet Gorge Hatchery (Figure 20). Fry size was probably the most important factor contributing to this increase. Fry release strategies were similar in 1986 and 1987 (including number, location and time of release and Clark Fork River flow conditions), except for size which increased by 58% from 33 to 52 mm total length. The larger fry can be attributed to a sophisticated water tempering system at the hatchery that provided nearly optimal water temperatures for embryo and fry development and growth. The large rearing capacity of the hatchery permitted reduced loading densities, which also improved fry growth.

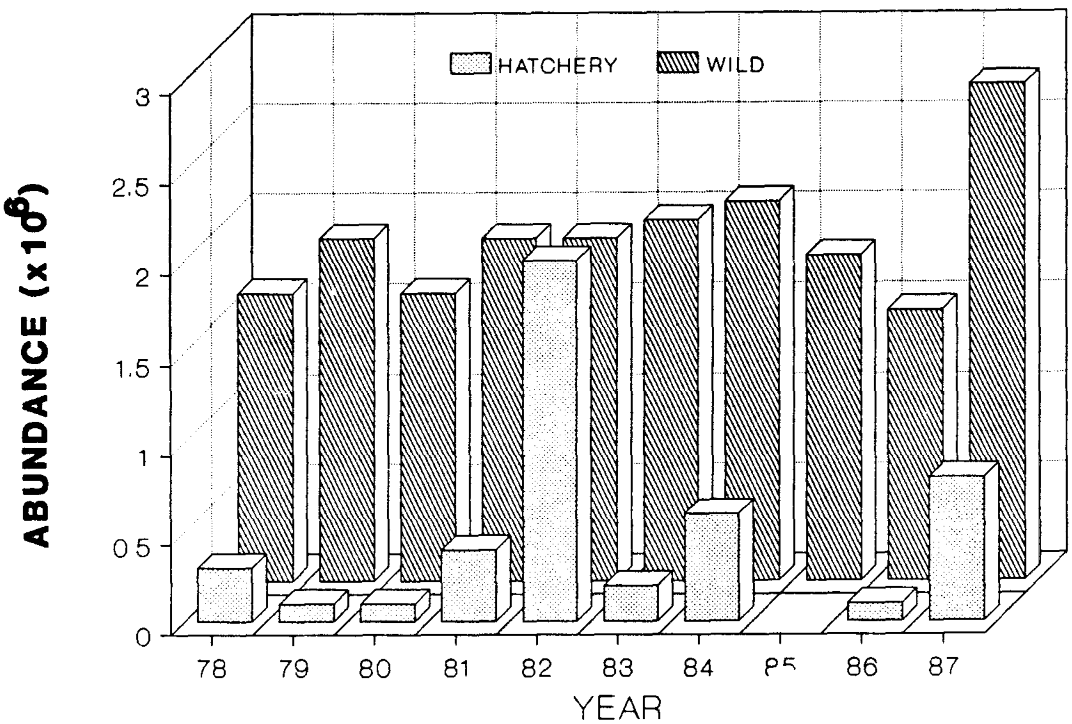

Figure 20. Total abundance of wild and hatchery-reared kokanee fry in Lake Pend Oreille, Idaho, during late summer, 1978 through 1987. Hatchery contribution in 1985 was not estimated.

The survival advantage of larger fry size is probably a result of increased ability to forage on noncladoceran zooplankton (copepods), increased swimming ability and predator avoidance and greater energy reserves for winter survival. The last point may have been critical for the 1985 year class. Fry recruitment in 1986 (1985 YC) was similar to previous years, but a large portion (56%) of the fry were small (<40 mm TL) wild fish that had emerged mid- to late summer (Bowles et al. 1987). Annual survival for this year class was nearly 20% lower than usual for age 1+ kokanee in Lake Pend Oreille, apparently because many of the small fry were unable to survive the winter (Bowles et al. 1986, 1987). This indicates a paradox because depleted early summer forage from mysid predation selects for later emergence of kokanee, whereas size-selective overwinter mortality selects for earlier kokanee emergence.

Hatchery fry survival in Lake Pend Oreille was much higher in 1987 than 1986, but survival must be enhanced further to meet rehabilitation goals. Kokanee population modeling indicated fry survival from time of release to fall sampling must approach 30% to meet the fishery harvest goal of 0.75 million kokanee annually. Although hatchery fry survival in 1987 was only 50% of this goal, attainment is not unrealistic. During past years, all hatchery fry have been released into Sullivan Springs Creek or Clark Fork River to maintain and/or enhance those runs for future egg needs. Fry survival associated with these releases is less than optimal, particularly in Clark Fork River. As surplus fry become available from increased hatchery production, other release strategies will be implemented to increase overall survival. Research will also determine the best strategie3 to optimize fry survival associated with maintaining Clark Fork River and Sullivan Springs runs. The combined result will increase fry survival and recruitment to meet program goals.

Improving fry survival during emigration from Cabinet Gorge Hatchery to Lake Pend Oreille is critical to the establishment of a run back into the hatchery. Survival of fry released into Clark Fork River was only 50% as high as Sullivan Springs releases during 1987 and appears to have been even lower in 1986 (Bowles et al. 1987). Poor survival during emigration is a result of inadequate flow conditions to "flush" fry quickly into Lake Pend Oreille, thus exposing fry to high predation, low food availability and increased disorientation and straying in the slack water of the Clark Fork River delta.

Fry survival can be improved during emigration by increasing nighttime flows and pulsing the flows to simulate a freshet. Providing this type of nighttime flow regime is difficult. Fry releases are usually delayed until midsummer to avoid an early season forage deficiency caused by mysid predation on zooplankton prior to thermal stratification. Nighttime flows in Clark Fork River are typically high during this early season from snowmelt and runoff, but decrease by midsummer. This is particularly evident during poor water years similar to the last two years. By delaying releases to ensure adequate forage in Lake Pend Oreille, we are increasing the potential for poor emigration survival due to low flow conditions. To avoid this problem, we recommend earlier releases of kokanee into Clark Fork River to correspond with the end of spring runoff to ensure adequate nighttime flows. Enhanced fry survival during earlier emigration should more than compensate for problems associated with lower food availability in Lake Pend Oreille. An additional advantage could be gained by maximizing fry growth at the hatchery to increase their ability to forage effectively on copepods, which are abundant in Lake Pend Oreille during early summer.

Highest priority for fry releases in 1988 will be to support Clark Fork River and Sullivan Springs runs. Based on 1987 survival rates, approximately 5.8 million fry are needed for the Clark Fork River and 3.2 million for Sullivan Springs to support an escapement of 75,000 kokanee and 15 million eggs for each site. Surplus fry will be used to evaluate other strategies, including open-water releases and fry barging in Clark Fork River.

Fry Marking

To evaluate release strategies, it is necessary to differentially mark large groups of fry released under ditterent conditions. During the past two years, we have evaluated several marks to determine their feasibility for marking large groups (1 to 5 million) of small (30-60 mm) fry.

Tetracycline (TM-50; administered in feed) has been used to differentiate hatchery-reared fry from wild fry in Lake Pend Oreille since 1978. Tetracycline is a•reliable mark, with negligible fry mortality and high retention for over two months (Bowles et al. 1987).

Fluorescent dye (Bismark Brown; applied by immersion) is an excellent short-term mark (<2 weeks), but short retention makes it impractical for long-term experiments (Fraley and McMullin 1983; Bowles et al. 1987). We will use dyes primarily for short-term fry emigration studies and to test sampling efficiencies.

Fluorescent grit has potential as a relatively long-term (>2.5 months) mark, but is time consuming to administer (<8,000 fry/man-hour), expensive ($1,350/one million fry) and stressful to fry (up to 15% initial marking mortality for 33 mm fry) (Phinney et al. 1967; Hennick and Tyler 1970; Bowles et al. 1987). Adjusting spray pressure to 70 lb/in^2 and distance to 30 cm from fry reduced marking mortality to less than 5% for 57 mm fry in 1987. This is acceptable mortality and allows us to use grit on a limited basis subject to the previously mentioned constraints.

Interpreting daily growth rings on kokanee fry otoliths has tremendous potential as a long-term mark. In 1987, a time-of-release check was successfully identified, which allowed differentiation of hatchery fry from wild fry and fry released into Clark Fork River from releases into Sullivan Springs Creek. In addition to distinguishing between hatchery and lake residence, otoliths from fry released into Clark Fork River had a wide, translucent (white) band indicating the time of release. This band was apparently a function of water temperature and represented the time fry spent in Clark Fork River and its delta.

Midsummer water temperatures in Clark Fork River were warmer than temperatures in Lake Pend Oreille and Cabinet Gorge Hatchery. Otoliths typically deposit a translucent calcium layer during periods of elevated temperature (Brothers 1985). In 1988, hatchery water temperatures will be manipulated to lay down a series of marks on fry otoliths. Temperature-induced otolith marks have been used successfully on lake trout Salvelinus namaycush (Brothers 1985).

Kokanee Forage Availability

Earlier forage availability may have improved fry survival in 1987. Wild kokanee fry typically emerge in June when fry are ineffective predators on fast-moving copepods, but can effectively utilize the slower-moving cladocerans (Rieman and Bowler 1980). Establishment of Mysis in Lake Pend Oreille has greatly reduced cladoceran production during early summer by predation prior to thermal stratification of the lake (Reiman and Falter 1981; Bowles et al. 1987). Although total zooplankton and cladoceran production in 1987 was similar to previous years, cladoceran production began nearly one month earlier than typical. Increased cladoceran abundance during early summer made these important forage items available to wild fry during their critical postemergent stage of development.

Several factors may have improved cladoceran production during early summer 1987. The Mysis population in Lake Pend Oreille declined by almost 50Z from 1986 to 1987. Mysids prey heavily on cladoceran zooplankton (Bowers and Vanderpoeq 1982), and this decline may have reduced overall predation. Mysids *prey* most effectively on cladocerans prior to thermal stratification of the lake. After stratification, Mysis are spatially segregated from these zooplankton by warm epilimnal waters. In 1987, an unusually warm spring in North Idaho resulted in thermal stratification of Lake Pend Oreille several weeks earlier than typical. Thus, the impact of Mysis on early summer cladoceran production was minimized by reduced mysid abundance and early lake stratification, resulting in high wild fry survival.

It should be noted that reduced Mysis abundance in 1987 does not necessarily indicate a declining population. Mysid populations near carrying capacity often undergo cyclic fluctuations (Lasenby et al. 1986), which may account for the apparent decline in Lake Pend Oreille populations. We will continue to monitor zooplankton and mysid populations to better define their relationship and impact on kokanee survival.

ACKNOWLEDGEMENTS

Vicki Wolkenhauer, through an educational cooperative with Spokane Community College, provided valuable assistance with sampling and fry-marking activities. Larry LaBolle assisted with trawling activities. Personnel from Cabinet Gorge and Clark Fork hatcheries were responsible for egg take and fry release operations and provided valuable advice throughout the year. Ed Schriever provided space at Cabinet Gorge Hatchery to conduct the fry marking study, and hatchery personnel assisted with the evaluation.

Roger Woodworth and Gary Stockinger from WWP were very cooperative and provided valuable advice in developing the fry release study. WWP provided the maximum possible nighttime flows during fry releases into the Clark Fork River. Fred Holm from BPA provided technical and administrative advice throughout the year. Jim Lukens and Virgil Moore reviewed the draft report.

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A P P E N D I C E S

Appendix A. Location and marking of hatchery-reared kokanee fry released in Lake Pend Oreille and tributaries.

Location	Date	Number of kokanee fry	Tetracycline-marked
Sullivan Springs	7/78	1,600,000	Yes
Sullivan Springs	7/79	1,745,730	Yes
Sullivan Springs	7/80	1,081,400	Yes
Sullivan Springs	7/81	2,219,800	Yes
Clark Fork River	7/81	1,933,600	Yes
Sullivan Springs	7/82	2,487,800	No
Clark Fork River	7/82	1,200,500	Yes
Clark Fork River	7/82	653,000	No
Scenic Bay	7/82	1,480,600	No
Pack River	7/82	21,300	No
Spring Creek	7/82	100,500	Yes
Gamblin Creek	7/82	8,400	No
Sand Creek	7/82	8,400	No
Strong Creek	7/82	8,400	No
Schweitzer Creek	7/82	8,400	No
Grouse Creek	7/82	7,700	No
East River	7/82	10,700	No
Hoodoo Creek	7/82	25,100	No
Priest River	7/82	22,500	No
Sullivan Springs	7/83	2,875,600	No
Clark Fork River	7/83	1,883,300	Yes
Clark Fork River	7/83	607,100	No
Strong Creek	7/83	12,000	No
Sand Creek	7/83	10,200	No
Schweitzer Creek	7/83	10,200	No
Pack River	7/83	25,500	No
Priest River	7/83	20,400	No
Grouse Creek	7/83	10,200	No
East River	8/83	20,400	No
Hoodoo Creek	7/83	25,400	No
Murphy Creek	8/83	17,000	No
Clark Fork River	7/84	645,034	No
Clark Fork River	8/84	1,011,594	No
Granite Creek	7/84	1,388,638	Yes
Granite Creek	7/84	1,204,886	No
Granite Creek	8/84	571,900	Yes
Granite Creek	8/84	49,088	No
Clark Fork River	7/85	1,209,128	No
Clark Fork River	8/85	1,325,095	Yes
Sullivan Springs	8/85	2,938,391	No
Granite Creek	8/85	489,888	No
Clark Fork River	7/86	10,014	No
Clark Fork River	8/86	3,392,882	Yes
Clark Fork River	9/86	12,621	No
Sullivan Springs	8/86	466,176	No
Sullivan Springs	8/86	1,128,555	Yes
Sullivan Springs	7/87	2,847,345	Yes
Clark Fork River	7/87	3,013,705	Yes

Appendix B. Kokanee age class density (number/hectare) in Lake Pend Oreille during late summer, 1987. A 90% error b and is listed with each estimate.

Age class	Origin	Lake section 1	2	3	4	5	6	Total
0+	Hatchery (total)	8.0+4.1	18+4.5	79+24	38+5.3	30+10	32+15	35+5.6
	SS release[a]	8.0+4.1	13+3.2	66+20	21+2.9	9.8+3.2	15+7.1	22+3.8
	CFR release[b]	0	5.1+1.3	14+4.1	17+2.4	20+6.5	17+8.3	13+2.2
	Wild	75+21	133+23	236+52	206+36	46+8.7	40+18	121+12
	Wild & Hatchery	83+24	150+22	315+61	244+38	76+15	73+13	157+14
1+	Wild & Hatchery	18+16	18+15	129+71	20+23	3.2+3.2	17+13	34+13
2+	Wild & Hatchery	74+46	2.1+3.4	4.1+4.5	66+33	58+17	25+17	37+9.9
3+	Wild & Hatchery	29+16	1.8+1.4	3.6+3.9	49+14	23+13	8.6+5.4	19+4.1
4+	Wild & Hatchery	29+11	18+10	4.0+3.8	36+12	24+12	5.2+4.6	19+0
Total	Wild & Hatchery	233+57	190+36	456+123	414+24	184+29	129+28	266+24

[a]Hatchery-reared kokanee fry released into Sullivan Springs Creek.
[b]Hatchery-reared kokanee fry released into Clark Fork River.

Appendix C. Statistical comparisons (ANOVA) of zooplankton densities and lengths among lake sections and years, Lake Pend Oreille, Idaho. Lake section abbreviations are: Southern = S, Central = C, Northern = N, Clark Fork River delta = D. Nonsignificant (P>0.10) contrasts are delineated by a common line under each contrast.

Zooplankter	P level for main effect: Lake section	P level for main effect: Year	Main effect contrasts (P>0.10): Lake section	Main effect contrasts (P>0.10): Year
Density				
Cyclops	0.000	0.008	S C N D	85 87 86
Diaptomus	0.000	0.002	C N S D	85 86 87
Epischura	0.160	0.022	S C N D	85 87 86
Bosmina	0.080	0.000	N C S D	87 85 86
Diaphanosoma	0.073	0.000	S C N D	85 87 86
Daphnia	0.100	0.031	N S C D	86 87 85
Total	0.000	0.001	C S N D	85 87 86
Length				
Cyclops	0.065	0.130	S C N D	85 86 87
Diaptomus	0.748	0.000	S N C D	85 87 86
Epischura	0.219	0.000	D N S C	85 87 86
Bosmina	0.612	0.003	C N S D	86 85 87
Diaphanosoma	0.092	0.005	S N C D	87 85 86
Daphnia galeata	0.208	0.078	C N S D	85 86 87
D. thorata	0.777	0.312	N S C D	85 86 87

Appendix D. Estimated year class abundance (millions) of kokanee made by midwater trawl in Lake Pend Oreille, Idaho, 1977 through 1987. The two oldest age classes were combined for estimates from 1977 through 1985.

Year class	Year estimated										
	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977
1986	3.55										
1985	0.78	1.66									
1984	0.84	1.15	1.79								
1983	0.43	0.68	1.03	2.63							
1982	0.42	0.54	1.24	1.51	2.14						
1981		0.24	0.37	1.21	2.28	3.84					
1980				0.27	0.50	2.77	2.31				
1979					0.29	0.64	1.36	1.69			
1978						0.87	0.79	1.00	2.01		
1977							0.74	0.96	1.31	1.82	
1976								1.03	1.70	0.71	2.01
1975									0.67	2.00	1.17
1974										1.29	2.95
1973											0.65
Total	6.01	4.27	4.47	5.62	5.21	8.12	5.20	4.68	5.69	5.82	6.78
Density (No./ hectare)	266	189	198	249	230	358	230	207	251	257	299

Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho

SPA project 85-339; IDFG project 03-68-997

EXPENDITURES

FY 1987 (January 1 through December 31, 1987 (January 31 billing))

CLASS TITLE	EXPENDITURES ($)
PERSONNEL	
Permanent Employees	40,632
Temporary Employees	2,216
Personnel Benefits	10,206
Total Personnel Costs	53,054
OPERATING	
Travel	2,834
Professional Services	103
Other Services	17,922
Communications	444
Material and Supplies	3,936
Rentals	5,198
Repair and Maintenance	3,065
Miscellaneous	357
Total Operating Costs	33,859
CAPITAL OUTLAY	
Equipment	5,541
Total Capital Outlay	5,541
Program Element Totals	92,454

Major property items purchased during FY 1987:

QUANTITY	ITEM	CLASS TITLE	EXPENDITURE ($)
1	IBM PC AT Computer	Capital Outlay	4,500
1	Computer Desk	Capital Outlay	175
1	Electric Winch	Capital Outlay	550
1	Camera	Capital Outlay	316
		Total	5,541

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